

**AN APPLIED BEHAVIOUR ANALYTIC APPROACH TO
CHALLENGING BEHAVIOURS SHOWN BY SURVIVORS OF
TRAUMATIC BRAIN INJURY**

By

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ABSTRACT

Challenging behaviours are often shown by survivors of traumatic brain injury, especially those with severe injuries. Challenging behaviours are a significant obstacle in the achievement of a successful rehabilitative outcome. A meta-analysis was conducted and it was found that interventions based on operant conditioning techniques were effective in treating challenging behaviours. However, the treatment outcome of learning-based interventions can be enhanced by predetermining the function served by the challenging behaviour. Various functional assessment methods can be used, which were analysed in this study. A detailed descriptive analysis was conducted with nine participants. The findings showed that challenging behaviours were precipitated and maintained by social contingencies. Further analyses revealed that functionally equivalent challenging behaviours were structured either hierarchically or sequentially. Identification of precursor behaviours can facilitate the rehabilitation process. A structured descriptive assessment was used for the first time with the traumatic brain injury population. This new functional assessment method proved to have great clinically utility.

DEDICATIONS

This thesis is dedicated to:

Kyah, my son, who seemed fascinated that I may write a 'book'.

Sheelan, my wife, who shared my highs and lows.

Kurda, my sister, who urged me not to fixate on details.

Sayah, my mother, who assisted in the completion of yet another doctoral thesis.

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OVERVIEW

This thesis begins with an introduction to traumatic brain injury. Chapter 1 opens with a definition of traumatic brain injury, which sets this piece of work within the discipline of acquired brain injury. The extent of traumatic brain injuries is then discussed. A thorough overview of the epidemiology of brain trauma will highlight the significance of this health issue. After that the causes and contributory factors of traumatic brain injuries are covered. This will show that the risk of brain trauma is associated with age, sex and socioeconomic position. Thereafter the reader will learn various classifications of traumatic brain injury. This shall be achieved by contrasting open- and closed-head injuries, primary and secondary mechanisms of damage and, finally, mild, moderate and severe brain injuries. This general introduction ends with a discussion of the prognosis after traumatic brain injury and the factors that influence recovery outcome.

The remaining two sections of Chapter 1 deal with the consequences of traumatic brain injury and treatment models. First, the literature concerning the physical, cognitive and neurobehavioural consequence of brain trauma will be examined. Emphasis shall be given to behavioural disorders commonly shown by survivors of traumatic brain injury. The problem of 'challenging behaviours' represents the focus of this thesis. It will be stated that challenging behaviours are a serious consequence of brain trauma, especially amongst those with severe injuries, which can significantly hinder rehabilitation. Afterward the impact of traumatic brain injury on social functioning will be discussed, in terms of interpersonal relationships, leisure and employment. Second, various models of treatment that are used with the traumatic brain injury population are considered. As the dominant paradigm, the medical model is considered initially. It will be argued that interventions based on medication alone are ineffective and serve only to suppress challenging behaviours in the short term. Interventions based on cognitive remediation will be shown to be more effective but it will be claimed that they are not amenable for survivors with severe, or even moderate, brain injuries. The advantages of the behavioural approach to treatment will be hailed. It will be reasoned that behavioural techniques can be tailored to suit all survivors of brain trauma, irrespective of the severity of their injury. The position adopted in this thesis is that behaviour modification programmes, based on operant conditioning, are most appropriate for treating challenging behaviours shown by survivors of traumatic of brain injury.

Chapter 2 continues with an introduction to applied behaviour analysis. This will outline the approach of scientifically examining behaviours, in respect of the behavioural model. The theoretical argument for why an accurate assessment of behavioural function is

needed in order to maximise the effectiveness of behavioural treatments is presented. The application of applied behavioural analytical approaches in other populations will be briefly described. The main body of Chapter 2 concerns assessments methods that can be used to appraise behavioural function. Different types of functional assessments will be outlined, which include indirect, direct and experimental methodologies. The literature will be closely examined to understand the advantages and disadvantages associated with specific functional assessment methods. Throughout, the balance between theoretical accuracy and clinical efficiency will be made clear. After the various functional assessment methods have been described, the chapter ends with a look at functional assessment techniques used specifically with the acquired brain injury population. A description of a rating scale that was developed specifically for use with brain injury survivors will be given. Then brain injury studies that have adopted functional assessments will be briefly summarised. This will highlight the limited use of applied behavioural analysis in the field of acquired brain injury.

The first empirical study is presented in Chapter 3. This meta-analysis investigates the effectiveness of behavioural treatments of challenging behaviours. It also considers the extent to which treatments studies conducted functional assessments. It shall be claimed that this research extends the meta-analytical literature, by focusing on the treatment of challenging behaviours, only including studies that used some form of consequent-based behavioural treatments and using effect size to appraise the effectiveness of interventions. The findings will show that behavioural interventions are generally effective in the treatment of challenging behaviours, despite little evidence for the systematic use of pre-intervention functional assessments.

The second empirical study is presented in Chapter 4. This work applies an observational methodology to conduct direct functional assessments with traumatic brain injury survivors. It is claimed this research is novel as it uses computer-based technology to assess the function of challenging behaviours in the brain injury population. Moreover, the study analyses specific topographies, which include non-aggressive forms of challenging behaviours. The findings support the contention that challenging behaviours are mediated by environmental events. This work extends the applied behaviour analysis literature in many ways. It shows that behavioural function can be derived using this kind of detailed assessment. It also provides support for reciprocal nature of challenging behaviours shown by survivors of traumatic brain injury.

The work shown in Chapter 5 is an extension of the preceding study. This work is presented as two separate studies. In the first study, the descriptive data are further analysed to investigate the organisation of challenging behaviours. The findings of the preceding study

showed that some challenging behaviours were functionally equivalent. The study will show how these behaviours were structured. This analysis will be conducted for both aggressive behaviours and other habitual challenging behaviours. The findings support the claim that some functionally equivalent challenging behaviours were structured or occurred sequentially. The existence of precursor behaviours has important clinical implications. The second study will examine the immediate effects of restraint and seclusion on challenging behaviours. It shall show that in some cases punishment techniques are not always successful in reducing the target behaviour in the short term. Moreover, the findings indicate that such management techniques may also evoke collateral increases in other challenging behaviours. The study will be concluded by offering a depiction of all the findings at a participant level. This will offer a theoretical and practical summary of the chain of events and behaviours that were typically observed, which has great clinical significance for designing interventions.

The main practical limitation of such a descriptive analysis is that it is time consuming. The last empirical study, shown in Chapter 6, will conduct a novel functional assessment of challenging behaviour, known as a structured descriptive assessment. This new technology is a hybrid of descriptive and experimental approaches. The study improves on previous applications of the approach by using effect size and conditional probability calculations in its analysis. The findings will show that structured descriptive assessments can be applied to the traumatic brain injury population, in order to yield valuable information on behavioural function efficiently.

The overall findings of the thesis will be summarised in the final chapter. The limitations of the empirical studies will be outlined also. Suggestions for the direction of future research will be provided as well as a discussion of the clinical implications of this work.

CHAPTER 1 TRAUMATIC BRAIN INJURY

1.1 INTRODUCTION

The term acquired brain injury encompasses all types of neurological disorders that are not congenital or degenerative. There are two subsets of acquired brain injury. One type of acquired brain injury has an intrinsic derivation and does not involve an external mechanism. Such non-traumatic brain injuries may be caused by heart attacks, strokes, aneurisms, intracranial tumours, infectious diseases, venereal diseases, meningitis, hypo/hyperglycaemia, hypoxia and toxic exposure. The second type of acquired brain injury, known as traumatic brain injury, is caused by the impact of an external force. Traumatic brain injury is clearly defined in the following statement:

“Traumatic brain injury is an insult to the brain, not of a degenerative or congenital nature but caused by an external physical force, that may produce a diminished or altered state of consciousness, which results in impairment of cognitive abilities or physical functioning. It can also result in the disturbance of behavioral or emotional functioning. These impairments may be either temporary or permanent and cause partial or total disability or psychosocial maladjustment.” (Brain Injury Association of America, 1986)

It should be noted that the rehabilitation needs of acquired brain injury survivors are likely to be similar, regardless of whether the injury was caused by trauma or not (Soryal, Sloan, Skelton, & Pentland, 1992). Consequently, the sequelae of traumatic brain injury outlined in this literature review may be relevant to the non-traumatic brain injury population.

This thesis focuses on disturbances of behavioural functioning that are shown by some survivors of traumatic brain injury. Such behaviours may be harmful to the survivor, challenging to carers and/or socially unacceptable. Various terms have been used to describe such behaviours, such as abnormal, aberrant, disturbed, dysfunctional, maladaptive or problem behaviours. The terms used throughout this thesis is challenging behaviours. Challenging behaviour has been defined as:

“culturally abnormal behaviour(s) of such an intensity, frequency or duration that the physical safety of the person or others is likely to be placed in serious jeopardy, or behaviour which is likely to seriously limit use of, or results in the person being denied access to, ordinary community facilities” (Emerson, 1995, p.4-5).

Traumatic brain injury is a significant cause of death and disability, particularly amongst people below the age of 35 years (Seel *et al.*, 2003). The societal cost of traumatic brain injury is substantial (Ghajar, 2000). Survivors may require a multitude of services to aid

their recovery. The process of rehabilitation may include acute care, rehabilitation nursing, physiotherapy, occupational therapy, social care work, counselling, day-centre and home-based support services and, for younger survivors, specialist educational provision. The financial burden of providing neurorehabilitation care is amplified by the age distribution of head trauma injuries, given that a third of survivors are aged between ten and 19 years (Rimel, Jane & Bond, 1990). The repercussion of acquiring brain injury at a young age is that individuals will spend considerably longer living with the consequences of their disability and, hence, society will spend longer providing rehabilitative care. The personal costs involved with poor outcome following traumatic brain injury are also extensive and pervasive. Empirical studies document adverse long term effects for brain injured individuals and their families in terms of emotional well being and social and occupational functioning.

In this review, the epidemiology of traumatic brain injury is summarised in terms of incidence, type, severity, mechanisms of injury and the demographic characteristics of sufferers. This will be followed by an outline of the physical, cognitive, emotional and behavioural impairments that invariably follow traumatic brain injury, which are often associated with challenging behaviours. The effects of these deficits in terms of interpersonal and occupational functioning will be described. This will be followed by a discussion of the major treatment models of brain injury, namely medical, cognitive, and behavioural approaches. It will be argued that patients' subsequent impairments may limit the relevance of particular rehabilitative approaches and that pharmacological approaches may exacerbate deficits under some circumstances. For individuals with emotional and behavioural disturbance following traumatic brain injury, therapeutic efforts are further hindered by the challenging behaviours they exhibit. Before successful rehabilitation can occur, identification and analysis of the challenging behaviours are required. It will be posited that methods of functional analysis based upon behavioural principles are the most appropriate means to measure and understand challenging behaviours that act as barriers to rehabilitation. This allows treatment to focus upon the elimination or reduction of challenging behaviours that are undermining the rehabilitation process. Rehabilitation can then occur, maximising the possibility of improved recovery and good outcome.

1.2 EPIDEMIOLOGY OF TRAUMATIC BRAIN INJURY

The extent of traumatic brain injury has been described using incidence and prevalence analyses. Incidence relates to the number of new cases arising within a particular time period whereas prevalence pertains to the total number of survivors at a point in time (Bryden, 1989). The prevalence of traumatic brain injury has not been reliably calculated for

the UK population (Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006). A comprehensive series of incidence studies was conducted in the 1970's by a Scottish group that included Jennett, Murray and MacMillan. Since then only a limited number of incidence reports for the United Kingdom have been published. The majority of epidemiological studies have been conducted in relation to the brain injury population in the United States. The absence of any universally accepted definition of traumatic brain injury has contributed to the paucity of consistent epidemiological reports.

The majority of incidence reports are retrospective studies of data records for hospital admissions. The methodology has associated weaknesses. Hospital admission data may be inaccurate for a number of reasons. First, admission data do not account for all the brain injury survivors who are not admitted to hospital or seen by a General Practitioner. Indeed many people who sustain only mild injuries may not even seek any medical attention. Further omissions include those cases where death has occurred at the accident scene or before admission to hospital (Jennett & MacMillan, 1981). Additionally, head injury fatalities may be attributed to causes other than the brain trauma, especially if extensive multiple injuries are presented (Miller, 1993). Conversely, hospital admission data can inflate the actual incidence unduly if records are counted more than once. This can occur when a patient is transferred between acute hospitals or readmitted with delayed complications (Jennett, 1996). Comparisons across incidence studies may be difficult given that different hospitals have dissimilar admission criteria (Wade & Hewer, 1987). Also a change in policy of a hospital may cause a sudden change in subsequent admission rates, which confounds any appraisal of the changes in incidence over time (Miller & Jones, 1985). In response to some of these weaknesses, some epidemiological studies have proposed attendance at an emergency department as a more suitable measure of community incidence (Jennett *et al.*, 1981; Yates, Williams, Harris, Round, & Jenkins, 2006).

Jennett and MacMillan (1981) have presented the most comprehensive epidemiology data for the United Kingdom (excluding Northern Ireland). The authors used routinely published statistics and a collection of prospective and retrospective surveys, by the Scottish study group (Galbraith, Murray, & Patel, 1977; Jennett *et al.*, 1977, 1979; MacMillan, Strang, & Jennett, 1979). Jennett and MacMillan (1981) reported an annual attendance rate of head injury survivors of 1,780 per 100,000. Incidence, based on admission rates for England and Wales, was found to be 270 per 100,000 (range between 210 and 360). The rate for Scotland was estimated to be 313 per 100,000. An annual mortality rate of nine per 100,000 was reported, which represents 1% of the total deaths in the United Kingdom. Head injuries

account for 15% of all deaths in the 15–24 years age group. The incidence rates in these findings are considerably higher than those reported in more recent incidence studies.

Yates and colleagues (2006) found an annual attendance rate of 453 per 100,000 in a retrospective study of hospital attendance over six years. This incidence is 25% lower than those proposed 25 years previously. Johnson and Gleave (1987) examined the records of the one hospital that received head injuries for a regional health authority in England. A population of 266,000 was surveyed over a year period. The calculations were adjusted to include local residents who were admitted outside the catchment area. They reported an annual incidence rate of 161 per 100,000. Using extrapolation techniques, it was estimated that around 80,000 new admissions for brain injury occur in England and Wales each year. Hawley and colleagues (2003) conducted the first large-scale population-based study of English children. An annual incidence rate of 280 per 100,000 children was found. This figure is similar to the incidence rate of 335 per 100,000 children reported by Tennant (2005).

The discrepancies between the older and more recent epidemiology studies can be attributed to improvements in record keeping systems and more efficient data retrieval processes. Alternatively such differences may represent a genuine variation in location. It has been noted that incidence figures tend to vary widely across studies (Johnson & Gleave, 1987). The diversity in the socioeconomic backgrounds of different populations may account for such inconsistencies in incidence. Tennant (2005) examined incidences across nine Health Authorities and ten Primary Care Trusts using socio-economic data, from the UK Department of Health. The overall incidence rate was reported to be 229 per 100,000. The rate varied by a factor of 4.6 across the Health Authorities, from 91 per 100,000 (Brent and Harrow) to 420 per 100,000 (Liverpool). Incidences also varied by a factor of 4.6 across the Primary Care Trusts. Incidence studies of traumatic brain injury in other countries provide additional support for geographic variations. Kraus and Chu (2005) reviewed epidemiological studies conducted in the United States. The adjusted average rate was calculated to be 120 per 100,000. This figure is not markedly different to those reported in the recent UK studies. Surprisingly, more variation in incidence rates is found between UK and European studies. An average European incidence of 235 per 100,000 has been reported, in a comprehensive review of epidemiology studies (Tagliaferri *et al.*, 2006).

The change in incidence over time may also represent a shift in time-specific incidence rates. Wittenberg, Sloan & Barlow (2004) reported a significant increase in the number of head injury admissions at Leeds General Infirmary. With only two exceptions, year-on-year increases were recorded over a 12-year period. No significant change in survival rates was found. Other authors have found that the number of deaths and disabilities resulting

from traumatic brain injury has reduced over time (Miller *et al.*, 1985; Miller, Jones, Dearden, & Tocher, 1992; Berney, Favier, & Rilliet, 1995; Burdett-Smith, Airey, & Franks, 1995). This has been attributed to technological advances, rapid emergency transport and improvements in the medical management of head injuries (Mahoney *et al.*, 1983; Ghajar, 2000). However, a decrease in mortality rates means a greater number of survivors, and so an increase in the prevalence of traumatic brain injury. Reported decreases in the incidence of traumatic brain injury may also be attributable to the decline in road traffic accidents. This decline may reflect improved road safety, vehicle safety designs, seatbelt legislation or greater enforcement of alcohol- and speed-limits (Miller *et al.*, 1985; Miller *et al.*, 1992; Jennett, 1996).

1.3 CAUSES AND CONTRIBUTORY FACTORS OF TRAUMATIC BRAIN INJURY

The leading causes of traumatic brain injuries are road traffic accidents, falls, assaults, occupational injuries and sporting or recreational activities (Richardson, 2000). The distribution of the causes of traumatic brain injury varies according to age, sex, injury severity and location. For instance, regarding regional variations, the proportion of trauma cases caused by road traffic accidents ranges from 24% in Scotland (Jennett *et al.*, 1981) to 90% in Taiwan (Lee *et al.*, 1990). Similarly, the likelihood of a brain injury survivor being the victim of an assault is 1% in France (Tiret *et al.*, 1990) and 42% in South Africa (Nell & Brown, 1991). The association between cause and injury severity is also documented (Jennett, 1996; Hawley, Ward, Long, Owen, & Magnay, 2003). Road traffic accidents are the most common cause of severe traumatic brain injury, accounting for between 58% and 70% of all trauma-related deaths (Tiret *et al.*, 1990; Teasdale, 1995).

The causes of traumatic brain injury are also related to the sex and age of the survivor. The risk distribution of brain trauma in terms of sex is clearly distinguishable. All incidence reports indicate that men are substantially more likely to suffer brain trauma. The European Brain Injury Consortium survey states that 74% of reported cases were men (Murray *et al.*, 1999). A review of 20 epidemiology studies found that the ratio of men to women varied from 1.5:1 to 3:1 (Tagliaferri *et al.*, 2006). A similar range of ratios, between 1.6:1 and 2.8:1, was found across thirteen North American epidemiology studies (Kraus & Chu, 2005). The risk of traumatic brain injury is also significantly influenced by age. The highest risk group are children and young adults. They are more likely to fall or be involved in road traffic accidents, as pedestrians or cyclists (Jennett, 1996; Hawley *et al.*, 2003). They also have an increased exposure to recreational and sports activities (Baker, Fowler, Li, Warner, & Dannenberg, 1994). Jennett and MacMillan (1981) claimed that nearly three

quarters (73%) of all brain injuries were suffered by people below the age of 25 years, of which over half (53%) were below the age of 15 years. More recent UK prevalence and epidemiology studies have reported similar findings (Hawley *et al.*, 2003; Wittenberg, Sloan, & Barlow, 2004; Tennant, 2005). Wittenberg, Sloan and Barlow (2004) reported the greatest proportion of brain trauma survivors related to children below nine years of age (17%). Nearly half (48%) of all head trauma cases were below 30 years of age. According to Tennant (2005) nearly a third (32%) of admissions pertained to children under 16 years of age. Hawley and colleagues (2003) stated that children below 2 years of age represent nearly a fifth (18.5%) of cases. The other high-risk age group belongs to those older than 64 years (Kraus *et al.*, 2005). Elderly people are more susceptible to falls (Jennett, 1996) and are far more likely to die from their brain injury (Jennett *et al.*, 1981).

Socioeconomic status is another factor that has been found to be associated with traumatic brain injury (Tennant, 2005). A higher incidence of brain trauma is found amongst those with lower socioeconomic positions (Richardson, 2000). Especially with regard to severe injuries, brain trauma survivors from lower socioeconomic levels are significantly overrepresented in comparison to the overall population (McKinley, Brooks, Bond, Martinage, & Marshall, 1981). Studies based on UK hospital admission have found traumatic brain injury survivors were more likely to live in socially deprived geographic locations (Hawley *et al.*, 2003). Brain injury survivors residing in deprived areas have an increased likelihood of presenting assault inflicted injuries (Dunn, Henry, & Beard, 2003). The issue of social deprivation may be further linked to elevated levels of substance misuse. The use of alcohol has been implicated in the majority of traumatic brain injury cases (Kraus, Morgenstern, Fife, Conroy, & Nourjah, 1989; Deb, Lyons, Koutzoukis, Ali, & McCarthy, 1999; Thornhill *et al.*, 2000). Intoxication is a contributory factor in many road traffic accidents, particularly those involving pedestrians and cyclists (Jennett, 1996). Race-specific skewing of incidence, cause, type and severity of brain injury has been reported in South Africa (Nell *et al.*, 1991), which may reflect racial differences in economic status.

1.4 CLASSIFICATION OF TRAUMATIC BRAIN INJURY

Traumatic brain injury can be classified along several lines. One way is to group brain injury according to the type of insult to the head. Another is to specify the nature of the brain damage, in terms of its extent or its direct and indirect consequences. Additional classifications may be based on the mechanisms involved in producing the brain injury. These broad categories of brain injury types are discussed collectively in section 1.4.1. The other

way to classify brain injury is by the severity of the damage. Brain injury severity is covered separately in section.1.4.2.

1.4.1 Injury Types

An open head-injury occurs when an object pierces the skull and membrane lining of the central nervous system, thereby leaving the brain exposed. The damage usually is localised to the perforated area but it can be more widespread if fragments of bone enter the substance of the brain. Only a minority of brain injuries are of the open-head type (Jennett, 1996). It has been estimated that skull fractures account for only a fifth of all head injuries (Miller, 1993). A closed-head injury occurs when an external mechanical force causes the brain to be moved violently. The most common mechanisms are rotational injuries and acceleration-deceleration injuries (McNair, 1999). The former involves a rotational movement of the brain within the skull. The latter involves impact between the brain and the inner surface of the skull. If a moving object strikes a stationary head then the injury occurs at the site of impact, known as a coup injury. Whereas, if a moving head strikes a stationary object then additional damage also occurs on the opposite side of the impacted area, known as a contrecoup injury (Morrison, King, Korell, Smialek, & Troncoso, 1998). In all cases, brain tissue is not penetrated in closed-head injuries. The damage caused in closed-head injuries are usually localised to the sites of impact. However, the damage can be more diffuse if the brain shears against the skull (Flannery & Buxton, 2001).

These primary mechanisms of traumatic brain injury cause direct and immediate damage. Additional complications can also arise within moments of the injury or some time later. Such secondary injuries can include: haemorrhage, haematoma, increased intracranial pressure, brain swelling, hypoxia, insufficient blood flow, blood clot, blockage of cerebrospinal fluid and infection (Miller & Becker, 1982; Miller, 1993; McNair, 1999; Ghajar, 2000; Flannery *et al.*, 2001). Secondary brain damage is a fundamental concern given that it may lead to disability or death. One report has found recurrent traumatic brain injuries in 92% of fatal head injury cases (Graham *et al.*, 1989). So, a clear contrast exists between the initial severity of an injury and the ultimate degree of brain damage after complications. For instance, a prospective study found that 51% of patients who survived mild brain injuries were moderately or severely disabled a year later (Thornhill *et al.*, 2000).

1.4.2 Severity

The severity of brain injury relates to the amount of damage incurred through trauma. This can range from mild bruising to a prolonged coma, a persistent vegetative state or death. Severity is inferred from the extent and duration of alterations in responsiveness.

There are three generally accepted assessment measures to categorise severity of the injury during the acute stage. The most common is the Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974; 1976). This quantitative assessment rates the depth and duration of altered consciousness, along three parameters; eye opening, verbal response and motor response. The second measure is an assessment of 'Post-Traumatic Amnesia' (PTA), which appraises the time taken to regain recall of continuous memories. It is considered a more sensitive gauge of mild and moderate brain injury compared to the GCS (Bay & McLean, 2007). As such, extended versions of the GCS have been devised to incorporate amnesia as an additional factor (Nell, Yates, & Kruger, 2000; Batchelor & McGuinness, 2002). The third measure is the Loss of Consciousness (LOC), which refers to the duration of unconsciousness. As there is no definitive measure of brain injury severity, a classification system may use any combination of these three measurements (Rao & Lyketsos, 2000). Moreover, the measures may be used in conjunction with diagnostic tools that draw on additional predictor variables of outcome (Brewer & Therrien, 2000; McNett, 2007).

Three broad grades of severity are used to categorise brain injury; mild, moderate and severe. However, universally accepted definitions for the severity of brain injury do not exist (Petchprapai & Winkelman, 2007). Consequently, different sources often use contrasting inclusion criteria to determine severity, especially when using combined measures (Gasquoine, 1997). Even for single measures, the demarcations used for severity may sometimes overlap or be discontinuous. Also, some authors have proposed a fourth severity category to identify 'minor' brain injuries, as distinct from other mild and more serious forms of brain injury (Swann & Teasdale, 1999; Ouellet & Morin, 2006). Generally, a mild brain injury is generally defined by a GCS score of 13–15 (Jennett, 2002), LOC of less than 30 minutes (Rao *et al.*, 2000) and/or PTA of less than an hour (Teasdale, 1995). A GCS score of 9–12 (Jennett, 2002), LOC of 30 minutes to 24 hours (Rao *et al.*, 2000) and/or PTA of one to 24 hours (Teasdale, 1995) is classified as a moderate brain injury. Those with a severe brain injury have a GCS score less than 8 (Jennett, 2002), LOC of more than 24 hours (Rao *et al.*, 2000) and/or PTA of more than 24 hours (Teasdale, 1995).

Mild brain injuries represent the majority of brain injury cases. Estimates for the proportion of brain injury diagnoses classed as mild have ranged from 75% to 95% [75%, (Bazarian *et al.*, 2005); 79%, (Miller, 1993); 80% (Tiret *et al.*, 1990), 83%, (Hawley *et al.*, 2003); 90%, (Thornhill *et al.*, 2000); 95%, (Teasdale, 1995)]. The seriousness of mild brain injuries should not be underestimated. Such injuries can result in long-term problems that affect daily functioning (Gasquoine, 1997; de Kruijk *et al.*, 2002). The neurobehavioural deficits of mild brain injury may include: headaches, dizziness, attention difficulties, memory

lapses, sleep disturbances, fatigue, irritability, depression, anxiety, low motivation, poor planning, visual problems and heightened sensitivity to stimuli (Levin *et al.*, 1987; Alves & Barth, 1993; Youngjohn, Burrows, & Erdal, 1995). This group of symptoms has been termed ‘post-concussion syndrome’. However, the use of this term is controversial because of significant difficulties in establishing the aetiology of such symptoms and in making accurate diagnoses. The term ‘syndrome’ is a misnomer given that headaches and memory difficulties are the only typically reported symptoms (Levin *et al.*, 1987). Also the subjective nature of the reported symptoms prevents any kind of accurate evaluation or assessment of change. Symptoms are particularly prevalent immediately after injury-onset but then tend to recede with time. Still, around half of mild brain injury survivors reported suffering one or more symptoms between six and twelve months post-injury (Fenton, McClelland, Montgomery, MacFlynn, & Rutherford, 1993; Deb, Lyons, & Koutzoukis, 1999). This persistence can be considered to arise from a delay in awareness or onset of symptoms (Hellowell, Taylor, & Pentland, 1999). However, the dominant view, originally proposed by Lishman (1988), is that the aetiology of such complaints is organic initially and then psychological thereafter. Indeed, continued reports of post-concussion symptoms may be motivated by litigation claims for compensation (Youngjohn *et al.*, 1995).

Only a minority of traumatic brain injuries are severe. According to a review of European epidemiology studies (Tagliaferri *et al.*, 2006), severe injury types account for less than 10% of all traumatic brain injuries. The ratio of mild to moderate to severe traumatic brain injury is estimated to be 22:1.5:1. The fatality rate amongst those with severe brain injuries is 40% for coma admissions (Choi *et al.*, 1994). Of those that survive severe brain injuries, a small proportion (1%–3%) remain in a persistent vegetative state and some more (10%–20%) suffer severely disability for at least six months (Teasdale, 1995). Some common consequences of severe brain injury may include significant physical disabilities, long-term cognitive deficits, gross changes in personality, behaviour problems and poor emotional well-being (Stratton & Gregory, 1994).

1.5 PROGNOSIS

Recovery following a traumatic brain injury varies. In a Welsh study, predominantly of mild brain injury survivors, Deb and colleagues (1999) found that over half (58%) presented with no disability one year post-injury, 7% developed a severe disability and 10% either died or were in a persistent vegetative state. Fewer cases of good recovery (39%) and more cases of severe disability (21%) were reported by Thornhill and colleagues in a larger study of Scottish survivors with mixed brain injury severities. Still, the severity of injury does

not necessarily correspond to the extent of outcome (Anderson, Taylor, Jones, & Miller, 1994; Thornhill *et al.*, 2000). Mild brain injury may result in persistent problems and, conversely, survivors of severe brain injury can achieve an excellent recovery of function (Giles & Fussey, 1988; Williams, Levin, & Eisenberg, 1990; Macciocchi, Reid, & Barth, 1993). The proportion of such cases has been estimated to be 21% and 22%, respectively (Thornhill *et al.*, 2000).

Such findings demonstrate the relevance of individual differences to recovery outcome. Demographical variables influence not only the likelihood of suffering a traumatic brain injury but also its prognosis. The sex of the survivor can be one such factor that influences the extent of recovery. Women exhibit better occupational and educational outcomes than men with comparable injuries (Groswasser, Cohen, & Keren, 1998). Prognosis also varies with age. Elderly people have an increased chance of suffering more severe forms of brain injury and having poorer recovery outcomes (Johnstone, Childers, & Hoerner, 1998). Advancing age represents an increase in mortality rates from head injuries (Jennett, 1996), especially after the age of 60 years (Ghajar, 2000).

Younger age as a factor in outcome severity is disputed. The most widely accepted argument is that brain injury sustained during childhood is less detrimental than comparable damage in adulthood (Webb, Rose, Johnson, & Attree, 1996). This notion is attributed to the increased capacity of the developing central nervous system to reorganise itself and compensate for some deficits (Mahoney *et al.*, 1983). The other position is that brain injury sustained during critical and/or sensitive developmental periods may be more detrimental than when the nervous system has fully matured (Andrews, Rose, & Johnson, 1998; Hart & Faust, 1988). The effect of developmental plasticity could be limited beyond the age of ten years (Rose, 1988). Also, older individuals possess a greater quantity of crucial memories stored that may have a contributory role in recovery outcome (Thomsen, 1989). Severely brain-injured children have been shown to have the same level of occupational and social functioning skills as survivors who suffered brain trauma in adulthood, despite exhibiting greater deficits previously (Cattelani, Lombardi, Brianti, & Mazzucchi, 1998).

1.6 CONSEQUENCES OF TRAUMATIC BRAIN INJURY

Death is one consequence of traumatic brain injury. An estimated 10% of brain trauma victims die as a direct result of their injury (Giles & Clark-Wilson, 1993). The mortality rate amongst victims with moderate and severe brain trauma has been reported to be 7% (Hellawell *et al.*, 1999). Those that survive a traumatic brain injury experience physical, cognitive and psychosocial impairments, which encompass emotional, behavioural and social

functioning (Kersel, Marsh, Havill, & Sleigh, 2001). The broad range of disturbances following brain trauma can occur during the acute, post-acute and chronic phases (Seel *et al.*, 2003). Moreover these impairments are related and vary in terms of extent and combination. The disabilities faced by brain trauma survivors differ from one person to the next. As previously outlined, age and sex are common factors that influence recovery. Other factors associated with rehabilitation outcome include the extent and location of the brain damage, premorbid cognitive, physical and psychiatric functioning and the medical and social support received post-injury (Stratton *et al.*, 1994). It has been estimated that a quarter of traumatic brain injury survivors present significant residual complaints (Giles *et al.*, 1993).

The association between recovery outcome and brain injury severity is more relevant when considering short-term outcomes. A number of prospective studies have found that severity is highly predictive of outcome, particularly in the early stages of the post-injury period (Levin *et al.*, 1990; Dirkmen, Ross, Machamer, & Temkin, 1995; Cifu *et al.*, 1997; Hellowell, Taylor, & Pentland, 1999; Dawson, Levine, Schwartz, & Stuss, 2004). However, the link between long-term outcome and severity is more ambiguous. Skandsen and colleagues (2008) claimed that severity was an important predictor of global outcome amongst brain injury survivors ($n = 93$) three to eight years post-injury. On the other hand, Colantonio and colleagues (1998) did not find support for injury severity as a significant prognostic factor in long-term recovery (Colantonio, Dawson, & McLellan, 1998). Also, Wood and Rutterford (2006a; 2006b) reported that long-term psychosocial and intellectual outcomes exceed predictions made during the earlier stages of recovery. It has been suggested that long-term outcomes are better predicted by an interaction of multiple factors, such as pre-injury socio-demographic characteristics, injury severity variables, post-injury personal factors and post-injury environmental factors (Colantonio *et al.*, 2004; Devitt *et al.*, 2006).

1.6.1 Physical Impairment

Physical impairments are a highly probable consequence of traumatic brain injury. The problem is often exacerbated because those who face physical impairments usually experience frustration and depression (Neumann, 1995). Over a third (40%) of brain injury survivors sustain severe musculoskeletal injuries that affect mobility (Campbell & Parry, 2005). The neurological damage affects multiple systems that have an impact upon the physical sequelae of traumatic brain injury. These include motor impairments such as mobility loss, hemiparesis, gait disturbance, ataxia, involuntary movement and poor balance (Neumann, 1995). It is not only survivors of severe traumatic brain injury that experience such physical impairments. A high incidence of gait disturbance, poor balance and restricted

movements has also been observed amongst survivors of mild and moderate brain injuries (Campbell *et al.*, 2005). Seizures during the acute and post-trauma phase are common (Neumann, 1995). Post-traumatic epilepsy is often a residual disorder that persists in the long-term. Almost a third (29%) of those with severe injuries experience epileptic seizures 20 years after the injury (Thomsen, 1992). Minor visual deficits are common (McKinlay *et al.*, 1981) and severe visual defects can also occur (Thomsen, 1984; 1992). Other physical difficulties commonly faced by traumatic brain injury survivors include incontinence, speech and swallowing disorders (Neumann, 1995).

Physical impairments may improve or resolve with time but can also persist permanently (Brooks, Campsie, Symington, Beattie, & McKinlay, 1986). Schalén and colleagues (1994) found that between 40 to 50% of 106 adults with severe brain injury experienced continued coordination problems five to eight years post-injury. Using a smaller sample ($n = 31$), Thomsen (1992) reported motor impairments in the acute phase for all adult survivors of severe brain injury. These physical problems remained twenty years later for approximately two-thirds (65%) of these survivors. Of these, almost a quarter (23%) remained wheelchair users, nearly a third (29%) experienced moderate disabilities and 13% faced severe disabilities. An association has been reported between the extent of physical disability and the severity of brain trauma suffered (McKinlay *et al.*, 1981; Brooks *et al.*, 1986a; Masson *et al.*, 1997). Additionally, multiple physical impairments tend to co-occur and this compounds the functional limitations of survivors. An extensive cohort study ($n = 407$) found that 63% of survivors faced more than one physical disability (Masson *et al.*, 1997). Of those with severe brain injury, 34% were unable to wash, 19% were unable to dress and 25% were unable to walk. Another large ($n = 306$) retrospective cohort study, which examined long-term outcomes following moderate to severe brain injury, reported that approximately 5% of survivors were totally dependent for all basic daily living activities (Colantonio *et al.*, 2004). This study also found that more subtle chronic physical problems affected a greater proportion of brain injury survivors.

Another common difficulty faced by survivors of traumatic brain injury is fatigue. Clinically significant levels of fatigue are often reported shortly after injury by many survivors, including those with mild brain injury (Middelboe, Andersen, Birketsmith, & Friis, 1992). Nearly all (95%) of the 460 adults surveyed in one study reported being more fatigued since their injury (Ouellet *et al.*, 2006). Reports of fatigue can persist in the medium- and long-term particularly amongst those with more severe injuries (Ouellet *et al.*, 2006). However, these findings only related the presence of fatigue and did not provide any measure of its extent. The subjective perception of fatigue creates difficulties in defining and

measuring the phenomenon. Some studies have attempted to operationalise fatigue by using physical correlates of performance measures (Walker, Cardenas, Guthrie, Mclean, & Brooke, 1991; LaChapelle & Finlayson, 1998). Fatigue is a multi-faceted concept that comprises both physical and mental tiredness. It has been associated with various sleep disturbances and may be a direct consequence of sleep deprivation (Clinchot, Bogner, Mysiw, Fugate, & Corrigan, 1998). It has also been cited as a common manifestation of affective disorders, particularly depression (Kreutzer, Seel, & Gourley, 2001). In addition, recent research has indicated that fatigue may be a consequence of underlying cognitive impairments given the additional effort required to process information after the onset of neurological damage (Ouellet *et al.*, 2006; Ziino & Ponsford, 2006).

Finally, it is worth including sleep disorders as a common consequence of traumatic brain injury. The aetiology of sleep disorders experienced by brain-injured survivors is unclear. Sleep disorders may have a physiological origin caused by damage to those systems in the brain that regulate arousal or sleep-wake cycles. Alternatively, there may be a psychological explanation for sleep disorders that relates to stress. Sleeping disorders may be precipitated by the experience of stressful life changes and, as such, may be conceived as symptoms of depression and anxiety. Difficulties in sleeping may also contribute to other common difficulties such as irritability and fatigue (Ouellet, Savard, & Morin, 2004). They may also increase the risk of developing psychiatric disorders or may exacerbate cognitive impairments, including compromised concentration and memory (Ouellet *et al.*, 2004).

1.6.2 Cognitive Impairment

Cognitive impairments are a common consequence of traumatic brain injury. Cognitive deficits can be grouped into the following broad categories: perception, learning and memory, attention and communication (Stratton *et al.*, 1994). These categories are outlined below. However, it should be made clear that all cognitive processes are integrated and any deficits in one category invariably impact upon others.

The extent and duration of the cognitive deficits experienced by brain injury survivors have been found to be related to the severity of injury (Hellowell *et al.*, 1999). Schretlen and Shapiro (2003) conducted a large meta-analysis ($n = 39$) of the cognitive effects of traumatic brain injury, which encompassed differing severity and varying phases of injury. They found that cognitive deficits of those with moderate to severe brain injury were three times more serious than those with mild brain injury. It was reported that cognitive impairments extensively resolved within one to three months following mild traumatic brain injury. However, for the severely brain-injured population, despite improvements in cognitive

functioning during the two years after injury, pronounced cognitive impairments remained in the long-term.

1.6.2.1 Perception

Neurological damage in areas that govern sensory and attentional processes impinge upon the ability to discriminate, organise and interpret information, relating to the self and the external environment (Giles *et al.*, 1993). A variety of perceptual impairments can result. These include neglect disorders (inattention to particular aspects of the environment), various types of agnosia (inability to recognise percepts), body scheme disorders (inability to identify body parts or their spatial relations), visuospatial deficits and sensory losses. Such impairments in perception often underlie many physical difficulties. Apraxia can cause difficulties in performing purposeful actions, maintaining postures, moving on command, coordinating precise movements, engaging in rapid movements or learning new motor skills. Perseveration may also occur, which manifests in the continuous repetition of behaviours.

Some perceptual deficits may resolve over time. Thomsen (1992) observed visual recovery particularly with minor visual problems. However, severe visual impairments remained in over a tenth (13%) of the sample twenty years after injury onset. Other reports have suggested that even minor difficulties with vision may not resolve over time. Brooks and colleagues (1986a) discovered that over 40% of survivors were reported to have subtle visual difficulties one and five years following the injury.

1.6.2.2 Learning and Memory

The most common cognitive impairment following traumatic brain injury is impaired memory (Gloag, 1985). Regions of the brain implicated in memory processes include the medial temporal lobe, which incorporates the hippocampus, and the basal forebrain. Brain structures governing memory systems can be affected from direct or diffuse damage. Memory deficits are the most enduring cognitive impairment and are particularly difficult to treat (Gloag, 1985). An extensive study of long-term outcomes found that over half the sample (54%) presented significant memory problems (Colantonio *et al.*, 2004). It has been reported that the extent of memory deficits is associated with brain injury severity (Masson *et al.*, 1997; Hellowell *et al.*, 1999).

Memory deficits may arise from impaired arousal, attention, retrieval and/or encoding processes. Two types of memory impairment are often observed. Retrograde amnesia, where memory for events occurring prior to the injury is disturbed, is an impairment of long term episodic memory. Anterograde amnesia, where memory for events occurring after the injury is disturbed, is an impairment of consolidating new information in long term

memory. Both retrograde and anterograde amnesia can occur together. Difficulties in short term and working memory are also usual. Impairments in categorical knowledge have been documented (Giles, 1989). Severe amnesia may lead to confabulations, which relates to false, grandiose and absurd memories. In amnesic syndrome, the most severe form of memory impairment, memories cannot be retained long enough to carry out even simple behavioural sequences. This inability to attend, encode or recall information causes incapacity to plan and execute actions and learn information. Slower rates of learning and difficulties in generalising and initiating learned behaviours are typical consequences of memory problems (Giles, 1999). This poses a challenge to rehabilitative efforts, which typically require a mastery of new skills and the relearning of adaptive behaviours.

1.6.2.3 Attention

Attention can be conceptualised as “the capacity to focus on particular stimuli over time and to manipulate flexibly the information” (Sohlberg & Mateer, 1987, p.117). Numerous attention deficits may follow brain trauma (Mathias & Wheaton, 2007). Survivors may exhibit deficits in orient attention (Cremona-Meteyard, Clark, Wright, & Geffen, 1992), selective attention (Chan, 2000; Chan, Hoosain, & Lee, 2002), divided attention (Leclercq *et al.*, 2000) and sustained attention (Chan, 2000). Such deficits may lead to impairments in both automatic and controlled attention processing. Survivors may require conscious attention to engage in previously automatic activities and controlled attention processing may also be impaired. However, it is not clear whether such cognitive impairments reflect specific deficits. It has been argued that such impairments may be due to a more general disruption in information processing (Brouwer, Withaar, Tant, & Van Zomeren, 2002; Felmingham, Baguley, & Green, 2004). Experimental data have shown that traumatic brain injury survivors, irrespective of the severity of their injury, produce slower response rates and more errors in various tests of attention compared to controls (Ziino *et al.*, 2006). These deficits in attention, and/or information processing speed, also impact on memory, fatigue, task performance and skill acquisition.

1.6.2.4 Communication

Due to impairments in information processing and attention, language difficulties are common in the brain injury population. Long-term difficulties with reading, writing and word finding are reported frequently by survivors and their relatives (McKinlay *et al.*, 1981; Thomsen, 1984; Masson *et al.*, 1997). The gravity of the language deficits experienced varies. Neurological assessments have shown that the degree of language impairment shown by survivors with severe head injury was greater than those with only moderate injuries

(Hellawell *et al.*, 1999). However, communication difficulties are not limited to those with only moderate and severe head injuries. Significantly impaired verbal fluency was observed in individuals with mild brain injury, compared to healthy controls and patients with Parkinson's Disease (Raskin & Rearick, 1996). These differences were attributed to attention deficits and slower retrieval processes. The findings suggest that communication impairments may arise from memory deficits, attention disorders and perceptual problems.

Communication impairments can also be caused by direct damage to brain regions that govern language. However specific disorders of language function following brain trauma are rare (Richardson, 2000). Aphasia is a loss of the ability to produce or comprehend language that arises from damage to Broca's and Wernicke's area. Different classifications exist and the extent of the inability can vary. However, aphasia is a rare clinical disorder. The brain injury population is far more likely to experience dysphasia. Dysphasia relates to a group of subclinical disorders of comprehension and speech production. It is associated with generic left hemisphere damage, executive dysfunction and short term memory deficits (Stratton *et al.*, 1994; Wilson & Dailey, 1999). Receptive dysphasia relates to difficulties in understanding written and spoken words. Rehabilitation can be severely hindered by survivors' incomprehension of simple instructions and sentences. Although the impairment concerns the input of language, there can also be associated problems related to output. For instance, even though fluent speech is enjoyed by those with receptive dysphasia, the speech may be distorted or even unintelligible. The spoken words may contain irrelevant, illogical and digressive themes. Perseveration (repeating words and phrases) and echolalia (copying another's words) may also occur. Expressive dysphasia relates to difficulties in articulating speech, due to either the inability to form or pronounce words. The articulated speech is slow, monotonous and seemingly effortful. It is often characterised by word finding difficulties, word and syllable substitutions, new words and non-content words (McKinlay *et al.*, 1981). Expressive language problems are much more common, especially amongst those with severe brain injury (Richardson, 2000). Schalen and colleagues (1994) conducted various outcome tests, five to eight years post-injury, and found a prevalence rate of 22% for expressive dysphasia and only 3% for receptive dysphasia. However, the rate of articulation problems may be higher as mild language impairments may not be perceptible in a neuropsychological assessment but may be manifested during normal communication efforts.

1.6.3 Neurobehavioural Disorders

Neurobehavioural disorders are a commonly reported consequence of traumatic brain injury (Brooks, Campsie, Symington, Beattie, & McKinlay, 1986). They may be

conceptualised as behavioural and/or emotional dysfunction and, in some cases, may be similar to functional psychiatric disorders. Behavioural dysregulation is common during the acute recovery phase but many behavioural and emotional problems may continue after this. Longitudinal research has illustrated that often such problems may be chronic (McKinlay *et al.*, 1981; Brooks *et al.*, 1986b). Thomsen (1992) found nearly a third (32%) of 31 survivors demonstrated serious behavioural deficits up to twenty years post-injury. In a larger study ($n = 106$), Schalen and colleagues (1994) reported untreated psychiatric symptoms amongst 28% of survivors with severe brain injury. Other follow-up studies have suggested that the severity of neurobehavioural symptoms either persist or increase with time (Johnson & Balleny, 1996). The general pattern for most neurobehavioural deficits amongst those with severe brain trauma does not change with time (Lippert-Gruner, Kuchta, Hellmich, & Klug, 2006).

Of the neurobehavioural sequelae of traumatic brain injury, behavioural disorders can be the most distressing, particularly for the relatives of brain trauma survivors (Acorn, 1993). Behavioural dysfunction falls under the rubric of challenging behaviour. Behavioural disturbances are not only challenging for caregivers but they also present a challenge to the successful administration of rehabilitative therapy (Newcombe, Brooks, & Baddeley, 1980; Emerson, 2001). According to Giles (1999), challenging behaviours may be conceived on a continuum falling between the extremes of volition and organic. Volitional behaviours are conceptualised as those within the control of the individual and represent a chosen reaction to the injury (Wood & Burgess, 1988). They may be an expression of frustration or an attempt to control environmental events. Such behaviours may represent an emotional and psychological response to the negative social and interpersonal consequences faced following traumatic brain injury (Arlinghaus, Shoaib, & Price, 2005). Organic behaviours are conceptualised as those outside the control of the survivor that arise as a direct consequence of head trauma (Arlinghaus, Shoaib, & Price, 2005). It has been argued that such behaviours with a more organic aetiology may respond better to pharmacological management (Giles, 1999).

However, the characterisation of challenging behaviours in terms of this unilateral volitional /organic continuum is too simplistic. Challenging behaviours considered to be organic may in fact not improve in spite of neurological recovery. This suggests that organic challenging behaviours may also be learnt given a history of reinforcement. So, the proposed conceptualisation of challenging behaviours is inadequate, since it does not account for the influence of other factors. Also, practically, it is not possible to determine the aetiology of challenging behaviours or to measure the relative contribution of organic or volitional factors. Moreover, it should be noted, the concept of volitional behaviours is incongruent with a behavioural approach to challenging behaviours, as described in section 1.7.3.

Neurobehavioural disorders may be categorised in terms of negative and positive types (Wood, 1984; Wood *et al.*, 1988). This form of categorisation shall be adopted in this section. Negative problems relate to the absence or reduction of behaviours, which are behaviourally expressed as apathy or affective disorders. Positive problems relate to active or excessive behaviours, such as increased aggression, agitation, self-injury, inappropriate sexual behaviour. Diffuse cortical or brainstem damage is often associated with negative disorders, and frontal or temporal damage is typically involved in positive behaviour disorders (Wood *et al.*, 1988). Consequently, negative disorder types may be less amenable to psychological treatment and, as such, are more usually managed pharmacologically. It should be noted that comorbid neurobehavioural disorders are common amongst survivors of traumatic brain injury (Hibbard, Uysal, Kepler, Bogdany, & Silver, 1998).

1.6.3.1 Negative Syndromes

1.6.3.1.1 Apathy

Apathy is the decline in motivation and responsiveness to environmental stimuli. It is manifested as inertia, inactivity and indifference to new and previous activities. Consequently, initiative, self monitoring, problem solving skills, socialisation and goal-directed behaviour are typically reduced (Rao, Spiro, Schretlen, & Cascella, 2007). The severity of apathy ranges from no interest in resuming vital functions, such as eating, to lowered interest in leisure or learning (Freeman, 1999). This can have detrimental repercussions since it can effect survivors' engagement and participation in rehabilitation activities, especially in behavioural therapies that are based on incentives and rewards (see, Wood, 1984). Apathy has been associated with decreased functional level, caregiver distress, poorer outcome and treatment response (van Reekum, Stuss, & Ostrander, 2005).

The aetiology of apathy is unclear. Some have claimed that apathy is not associated with any specific structural lesion (Freeman, 1999). Others have found associations between apathy and damage to the frontal lobes and subcortical structures (Mattson & Levin, 1990; van Reekum *et al.*, 2005). Andersson and colleagues (1999) assessed apathy in brain injury patients by categorising them into one of four lesion localisation groups. They found that lesion localisation was closely linked to apathy, which indicated a purely physical aetiology.

Many studies have found increases in the incidence of apathy following brain trauma in comparison to retrospective accounts of apathy before injury onset (Thomsen, 1984; Johnson *et al.*, 1996; Kersel *et al.*, 2001). However such studies are based upon subjective reports provided by survivors and/or their relatives. Many of the behaviours reported in relation to apathy are similar to behavioural expressions of fatigue, depression and mobility

disorders. Kant and colleagues (1998) reported that 60% of patients ($n = 50$) presented apathy and depression in combination. This contrasts with the proportion of patients in the apathy only group (11%) and the depression only group (11%). It is unclear whether the association between apathy and depression represents a single pathophysiological process. Alternatively, apathy may be conceived as a specific neurobehavioural disorder distinct from other depression (Marin, 1991). The highest prevalence rate in traumatic brain injury studies amongst adults was 71% (Kant, Duffy, & Pivovarnik, 1998) and the lowest was 46% (Andersson, Krogstad, & Finset, 1999). Interestingly, the prevalence of apathy amongst children and adolescents has been found to be much lower (14%) (Max, Robertson, & Lansing, 2001). The prevalence of apathy amongst brain trauma survivors in a non-industrialised country was found to be similar to those obtained in western populations (Al-Adawi *et al.*, 2004).

1.6.3.1.2 Affective Disorders

Affective disorders can be classified as negative behaviour disorders as they form an active resistance to treatment and management. Affective disorders include depression, mania and mixed states. Affective disorders may be organic, arising as a direct consequence of damage to the brain. On the other hand, affective disorder symptoms may represent a psychological reaction to the injury itself. Jorge and colleagues (1993b) reported depression amongst 42% of survivors ($n = 28/66$). Of these, the majority (61%) exhibited symptoms of depression within 3 months of their injury. The remainder presented delayed onset depression that seemed to be mediated by psychosocial factors, such as deficient social functioning and maladjustment to the consequences of the injury. This indicates that delayed onset depression is essentially reactive in nature. Such depressive symptoms make the diagnosis of organic affective disorders especially complicated. Moreover, medication prescribed to manage such problematic consequences of brain trauma may cause depression as a side-effect (Freeman, 1999).

Depression experienced after the injury onset is similar to the clinical presentation of functional depression. Symptoms include appetite change, insomnia, fatigue, psychomotor retardation, tearfulness, decreased socialisation, suicidal thoughts, apathy and blunting of affect. Depression is associated with reduced motivation, which impacts upon the inclination of patients to recover and their ability to tolerate stress (Wood, 1987). Rehabilitative efforts are additionally hindered by the fact that depression reduces the capability to think flexibly and generalise new information (Gordon & Hibbard, 1992). The seriousness of depressive

disorders is highlighted by the finding that brain injury survivors are five times more likely than the general population to commit suicide (Teasdale & Engberg, 2001).

Empirical data indicate that depression is the most common affective disorder associated with the brain injury population (Jorge *et al.*, 1993a). However incidence rates vary widely across different studies. This can be attributed to a divergence in measures used to measure depression and differences in the samples, in terms of injury severity and time since injury onset. Hibbard and colleagues (1998) found major depression amongst 61% of survivors ($n = 100$) during the first year of their injury, which was ten times greater than the community base rate. A comparison of prevalence between brain injury survivors and adults with multiple traumas that did not involve central nervous system damage was made by Jorge and colleagues (2004). The demographic status of both groups matched and they corresponded closely in terms of functional impairment. Major depressive disorder was found in a third (33%) of the traumatic brain injury group ($n = 91$) compared to 7.5% in the comparison group ($n = 27$). This finding suggests that impaired neuropathological processes are an important contributory factor to the development of affective disorders. Similar prevalence rates for the brain injury population have also been reported in studies using larger samples. Kreutzer, Seel and Gourley (2001) used DSM criterion to diagnose major depressive disorder for 42% of brain injury survivors from a sample of 722 adults. The most common cited manifestations of depression were fatigue (46%), frustration (41%) and poor concentration (38%), which related to somatic, mood and cognitive symptoms respectively. A large ($n = 666$) prospective national study found 27% of survivors satisfied DSM criterion for a diagnosis of major depressive disorder (Seel *et al.*, 2003).

A history of mood and anxiety disorders seems to predict susceptibility to depressive symptoms (Jorge *et al.*, 2004). Identified risk factors include poor premorbid psychosocial functioning, lower socio-economic position, executive dysfunction, prefrontal lesions and a history of alcohol and drug dependency (Jorge *et al.*, 1993a, 1993b; Seel *et al.*, 2003; Jorge *et al.*, 2004; Jorge, 2005). Injury severity and time since injury have not been found to be related to depression (Seel *et al.*, 2003). Major depressive disorder has been associated with the presence of anxiety disorder and the occurrence of aggressive behaviours (Tateno, Jorge, & Robinson, 2003; Jorge *et al.*, 2004).

1.6.3.2 Positive Syndromes

1.6.3.2.1 Aggression

Traumatic brain injury survivors may present many different forms of aggression, each of which may have a different aetiology (Wood, 1984). Aggressive behaviours can be

manifested as verbal aggression, physical aggression or property destruction. Physical aggression, in particular, limits the possibility of recovery and community reintegration. Physical aggression can inhibit access to rehabilitative procedures or reduce the duration of therapy. Verbal aggression, which incorporates shouting or screaming, can be distressing for caregivers. Consequently, caregivers may either respond excessively to the verbal aggression or they may ignore the survivor, both of which can be problematic. Property destruction can be distressing, costly and a serious safety issue. Of all the neurobehavioural disorders, aggression has been found to have the greatest negative impact for caregivers (Marsh, Kersel, Havill & Sleight, 1998).

Aggressive behaviours are common in the severe traumatic brain injury population (Giles *et al.*, 1993). Brooks and McKinlay (1983) found that relatives of survivors reported significant behavioural changes after injury. The follow-up study conducted five years post-injury found a prevalence rate of 64%, amongst 42 survivors, and reported acts of physical violence in 20% of cases (Brooks *et al.*, 1986a). Moreover, the reported frequency rates had increased by a factor of two for physical aggression and by a factor of four for verbal aggression. The chronic nature of aggression has also been shown by various authors at stages of follow-up. Tateno and colleagues (2003) reported that a third (34%) of 89 survivors displayed aggressive behaviours during the first six months after the traumatic episode, which was considerably higher than the comparison group of victims of multiple trauma without brain injury. Using a sample of brain injury survivors with depression, Jorge and colleagues (2004) reported that over a half (57%) of 91 survivors had displayed aggression one year post-injury. Van Zomeren and Van Den Berg (1985) found irritability amongst 37% of 57 survivors two years post-injury. Oddy and colleagues (1985) conducted a follow-up reassessment seven years post-injury and reported an incidence rate of 43% amongst survivors with severe traumatic injuries. Even after 20 years a quarter (26%) of 31 survivors were reported to have presented aggression, half of whom had engaged in physical violence (Thomsen, 1992).

The characteristic features of aggression following brain trauma include: reactive, reflective, purposeful, explosive, periodic and ego-dystonic types (Silver, Yudofsky, & Anderson, 2005). One way of categorising aggression generally is to distinguish between stimulus bound aggression and spontaneous aggression. Stimulus bound aggression is environmentally dependent. It is precipitated by some form of 'provocation' and, often, is goal directed. Due to cognitive deficits, brain injury survivors are more susceptible to misinterpreting external stimuli and so may misconstrue environmental events as threatening. Stimulus bound aggression can be territorial (Freeman, 1999). It is a form of exaggerated

defensiveness generally observed in uninhibited brain-injury survivors with frontal lobe damage. The violence is often short lived but it can persevere and escalate. Spontaneous aggression is rarer and thought to be seizure related. A discernable environmental trigger is generally absent and the aggressive episode is sudden, relatively long lived and poorly recalled by the protagonist.

Impairments in cognition and behaviour regulation impact on the ability to manage anger and tolerate stress. Temporal and limbic structures are thought to mediate emotions. Damage to these areas may increase emotional intensity, irritability and paranoia, each of which may increase the likelihood of aggressive behaviours occurring (Freeman, 1999). Temporal lobe damage often results in explosive types of aggression that are discrete, short-lived and have no obvious social trigger (Eames, 2001). Giles and Clark-Wilson (1993) have contended that aggression may arise from a reduced ability to cope with the frustrations of dependence and inability to achieve formerly simple activities. They have observed that for some patients, (stimulus bound) aggression is essentially a learned means of controlling their environment, avoiding unwanted tasks and obtaining attention or goods. Furthermore, they have argued that head trauma may aggravate a premorbid predisposition to aggression. This contention has been supported by other authors. Greve and colleagues (2001) found that survivors with impulsive and aggressive premorbid personalities, who had limited social skills, were more likely to engage in aggressive behaviours post-injury. Tateno and colleagues (2003) also discovered clinical correlates for aggression. Aggressive survivors were found to have a significantly higher frequency of a major diagnosis of depression, a mood disorder, alcohol abuse, substance abuse and poor premorbid social functioning.

Non-specific agitation is also common following severe brain injury. Agitation is an early sign that the survivor is emerging from coma. The agitation is associated with uninhibited and seemingly random movements, restlessness and disorientation (Angelino, Miglioretti, & Zotti, 2002). Later agitation is more specific and can result in aggression against others, objects or the self. It may be initiated by over stimulation or a reduced capacity to cope with environmental stimulation (Giles *et al.*, 1993). These behaviours will pose barriers to rehabilitative efforts (Angelino *et al.*, 2002).

1.6.3.2.2 Self-injury

Self-injurious behaviour is more commonly observed in populations with developmental disorders. Self-injury is a secondary feature of traumatic brain damage (Winchel & Stanley, 1991). However the form of self-injury exhibited is qualitatively different to those displayed by the other groups. Brain trauma survivors may not be able to

exhibit all topographies of self-injury due to restrictions in their physical mobility. Examples of self-injury topographies exhibited by brain injury survivors include head banging, self-hitting and self-biting. They are often presented alongside other forms of externally directed aggression. Self-injury may represent agitation and/or difficulties in managing arousal but it can develop into a learned behaviour (Giles *et al.*, 1993).

1.6.3.2.3 Inappropriate Sexual Behaviour

Inappropriate sexual behaviours incorporate any physical or verbal act of a sexual nature that is unacceptable, given the social context of its occurrence (Johnson, Knight, & Alderman, 2006). The manifestation of sexual disinhibition can take a wide variety of forms, ranging from sexual offenses to less serious but socially unacceptable responses. Depending on the label and its definition, inappropriate sexual behaviours include sexual comments or gestures, unauthorised attempts at physical intimacy, touching another's body parts, voyeurism, exhibitionism, frotteurism, excessive or public masturbation and overt sexual aggression involving physical coercion (Wood, 1984; Britton, 1998; Simpson, Tate, Ferry, Hodgkinson, & Blaszczyński, 2001). All inappropriate sexual behaviours are harmful to the recipient, either physically, mentally or emotionally. They present problems for the individual, caregivers and the community.

A very small amount of research has been conducted on inappropriate sexual behaviours following brain trauma. Much of the associated literature has focused on sexual dysfunction within the context of consensual relationships. Various psychosexual complications are experienced by many brain injury survivors (Kreuter, Dahllof, Gudjonsson, Sullivan, & Siosteen, 1998). The aetiology of inappropriate sexual behaviour may be conceived in the same way as any other form of challenging behaviour. That is, it may be the product of premorbid personality, the sequelae of the brain injury itself and the social environment (Simpson *et al.*, 2001). In addition, inappropriate sexual behaviours may be viewed as secondary to the psychosocial consequences of brain injury, such as lack of interpersonal relationships, loneliness, depression or low self-esteem. An extremely limited amount of investigation has been conducted into the prevalence of inappropriate sexual behaviour in the brain injury population. A large scale ($n = 445$) retrospective file review found that 6.5% of patients had committed some form of sexual offense (Simpson, Blaszczyński, & Hodgkinson, 1999). The seriousness of this clinical issue however may be misrepresented by this unique estimate. The type of analysis conducted was prone to underestimate the actual rate, prevalence is unlikely to be identical across different service types and the impact was not considered (Knight *et al.*, 2008). For instance, Bezeau, Bogod

and Mateer (2004) reported that 70% of the neurorehabilitation staff surveyed reported sexual touching as a frequent problem and 20% claimed sexual force by patients was “common”.

1.6.3.2.4 Post-trauma Psychosis

Although relatively rare, there is a significantly greater incidence of psychosis amongst the brain-injured than in the general population (Thomsen, 1984; Arciniegas, Harris, & Brousseau, 2003). Thomsen, (1984) reported that 15% of severely brain injured individuals ($n = 6/40$), followed up ten to 15 years post-injury, had been hospitalised for over a year for psychosis. Post-traumatic psychoses differ from primary (functional) psychotic disorders with regard to age of onset and often occur after a long duration after injury onset (Fujii & Ahmed, 2002). Temporal and frontal lobe injury, abnormal electroencephalographic (EEG) activity and the presence of impaired visuospatial processing, poor memory and executive dysfunction are significantly associated with post-traumatic psychoses (Fujii & Ahmed, 2002).

The most common symptoms of a post-trauma psychosis are delusions and hallucinations (Fujii & Ahmed, 2002). Delusions are incorrect beliefs regarding oneself or others, in the presence of clear contradictory evidence. Hallucinations are sensory perceptions in the absence of sensory stimuli. Survivors may present with some symptoms of schizophrenia but thought disorders, catatonia and aspontaneity are uncommon (Arciniegas *et al.*, 2003). Delusions are often congruent with mood states. Grandiose delusions are common in brain-injured patients suffering mania and guilt delusions are common in those suffering depression (Freeman, 1999). Hallucinations are far more likely to be auditory than visual (Fujii & Ahmed, 2002). Delusions and hallucinations have a propensity to be short lived and temporally inconsistent (Freeman, 1999). Post-traumatic psychosis tends to be less organised and regular than primary psychotic disorders (Freeman, 1999). However paranoid states are stable and occur commonly amongst those with extreme brain injury (Thomsen, 1984).

There is a high possibility of misdiagnosis of post-trauma psychosis. It may be difficult to discriminate psychotic delusions from confabulations exhibited by brain-injured survivors (Flint, 1991). Cognitive impairments arising from head trauma may invoke disorganised thoughts, speech, emotions and behaviours that are highly similar to positive and negative schizophrenic symptoms (Arciniegas *et al.*, 2003). Hallucinations may not be symptomatic of post-trauma psychosis but may in fact be due to the cerebral insult or side-effects of prescribed medications. Sensory illusions are common amongst the brain injury population and these may result from perceptual and information processing deficits (Freeman, 1999; Arciniegas *et al.*, 2003). As such, cognitive remediation may improve psychotic symptoms (Arciniegas *et al.*, 2003).

1.6.4 *Social Functioning*

Head trauma survivors may suffer extensive disruption to many aspects of their psychosocial functioning (Kersel *et al.*, 2001). Social maladjustment is a common consequence of traumatic brain injury. Social behaviour can be viewed as the product of cognitive and emotional processes. As previously discussed in section 1.6.2, cognitive impairments may cause difficulties in perception and self-regulation that can result in disturbed social interaction and poor social skills. Brain trauma survivors may have self-centred, paranoid, non-empathetic and disinhibited qualities that may cause disturbance and embarrassment to other people. The emotional and behavioural changes frequently evidenced by survivors may also be problematic for others. Moreover, survivors themselves may have a reduced desire for social interaction due to their depression and apathy. Also social communication may be seriously hindered if survivors exhibit receptive or expressive language difficulties (Stratton *et al.*, 1994). Impoverished interpersonal, occupational and recreational functioning may diminish a survivor's quality of life, to the extent that they may feel their life is no longer worth living. Traumatic brain injury survivors present a serious suicide risk. Survivors who take their own lives do so within three years of injury onset, on average (Teasdale *et al.*, 2001). An association between the likelihood of suicide being committed and brain injury severity has been reported (Teasdale *et al.*, 2001).

1.6.4.1 *Interpersonal Relationships*

The affect of maladaptive social functioning on marriages and close relationships can be devastating. Wood and Yurdakul (1997) found that almost half (49%) the individuals surveyed ($n = 131$), who were married when they suffered their brain injury, were either divorced or separated within seven years. Half of all engagements were terminated following the trauma. The majority (85%) of cohabiting relationships had broken down. Of those that were still married, 6% stated their spouse had become their caregiver. Relationship breakdowns were related to the duration of the relationship prior to the injury and time since injury. Longer relationships were found to be less likely to dissolve. Most relationships broke down between five and six years after injury, which indicates the strain of living with brain trauma increases with time (Wood & Yurdakul, 1997). The high rate of relationship breakdowns reported in the study may be attributable to the fact that the majority (76%) of participants had incurred severe or very severe head injuries. Kersel and colleagues (2001) interviewed the caregivers of 65 adults with severe brain trauma at six and twelve months post-injury. The majority of participants had made good recoveries after six months but 29% were moderately disabled and 31% were severely disabled. It was found that 62% of

marriages had broken down within a year of injury. Although the follow-up was limited to twelve months, the findings show that relationships may dissolve relatively quickly for those with severe injuries. Similar results are reported in another longitudinal study conducted by Tate and colleagues (1989). They followed up brain injury survivors, on average, six years post trauma and categorised 85 of them according to their psychosocial disability. In relation to the moderate and severe disability groups, 63% ($n = 12/19$) of pre-trauma marriages had broken down and 83% ($n = 19/23$) of those who were single at the time of injury remained single. All the spouses of those survivors with severe disabilities were essentially caregivers.

In addition to physically intimate relationships, traumatic brain injury survivors also experience detrimental changes in their relationships with friends and relatives. Weddell and colleagues (1980) investigated changes in social adjustment by obtaining social outcome data from the relatives ($n = 44$) of severe head trauma survivors two years post trauma. They conducted comparisons with the premorbid functioning of a matched group of very recent brain injury patients. In contrast to the premorbid comparison group, traumatic brain injury survivors had significantly fewer friends and made or received fewer social visits. Family relationships were also different with significantly greater levels of friction amongst the brain injury group. A follow-up study was conducted seven years post trauma that included 33 of the original experimental participants (Oddy, Coughlan, Tyerman, & Jenkins, 1985). Sixty per cent had no life partners and remained friendless. Only those patients who had been able to resume working had got married or maintained satisfactory interpersonal relationships. Loneliness was the most difficult aspect of social maladjustment faced by brain trauma survivors. Kersel and colleagues (2001) reported deterioration in aspects of social contact at six and twelve months for a sample of 63 traumatic brain injury survivors. It was claimed that all survivors regularly visited friends before their injury but only 75% did so one year post-injury. A more pronounced decrease was recorded for visits from friends, which changed from 95% pre-injury to 59% after one year. The validity of the findings is weakened by the fact that pre-injury social functioning was measured retrospectively via caregivers. Difficulties maintaining social relationships were also reported by Tate and colleagues (1989). It was reported that 65% and 94% of those in the moderate and severe disability group, respectively, faced limited or complete social isolation.

More favourable findings have been reported by other authors. Schalen and colleagues (1996) examined psychosocial outcomes of survivors with severe head injuries ($n = 106$) five to eight years post-injury. Despite the physical and psychosocial deficits of survivors, only a small minority of patients and relatives reported that quality of life had deteriorated to such an extent that it was difficult to handle or unbearable. The authors

attributed these positive outcomes to improvements in rehabilitation services over time. Similarly, Klonoff and colleagues (2006) found good psychosocial outcomes for patients who had participated in comprehensive rehabilitation. Although the sample ($n = 93$) mainly comprised adults with moderate or severe brain injuries, the majority (81%) were in a stable relationship at follow-up. The findings of improved coping and adaptation skills were attributed to the emotional support provided by life partners and education.

As mentioned, spouses and relatives of brain injury survivors are often compelled to assume the responsibility of a caregiver. Consequently, in addition to the survivor, related caregivers may also experience changes in their social and psychiatric functioning. From the moment of discharge, some families provide life-long support and care for their brain-injured family member (Tate, Lulham, Broe, Strettle, & Pfaff, 1989; DeJong, Batavia, & Williams, 1990; Flanagan, 1998). The dependence of survivors on their related caregivers placed considerable stress on the family unit (Acorn, 1993; Stratton *et al.*, 1994). Longitudinal research has found that family caregivers experience feelings of distress, burden, anxiety and depression (Semlyen, Summers, & Barnes, 1998; Marsh, Kersel, Havill, & Sleight, 1998). These experiences often increase with time (Brooks & Mckinlay, 1983) and may correspond to changes in adaptive behaviours exhibited by brain trauma survivors brain (Brooks *et al.*, 1986b). Family caregivers have reported that psychosocial functioning was most significantly affected by survivors' inability to control negative emotions (Brooks *et al.*, 1986a). The social isolation element of their care duties gives rise to stress (Willer, Allen, Liss, & Zicht, 1991) and depression (Gillen, Tennen, Affleck, & Steinpreis, 1998). Clinically significant levels of anxiety and depression were reported by 39% of family caregivers six months after the survivor's injury onset (Marsh, Kersel, Havill, & Sleight, 1998) and these levels were maintained after twelve months (Marsh *et al.*, 1998). Other social difficulties have been reported by relatives as early as three months after injury onset (Livingston, Brooks, & Bond, 1985b) and have continued throughout the first year (Livingston, Brooks, & Bond, 1985a).

1.6.4.2 *Leisure and Social Activity*

A reduced participation in leisure and social activities has been a well documented consequence of traumatic brain injury. This can be due to a loss of friends and work colleagues or due to reduced motivation and interest on the part of the survivor, or a combination of both factors. Survivors who were unable to work have been reported to have few social interests and leisure activities (Oddy *et al.*, 1985). The extent of social engagement and subjective experiences of boredom may reflect the injury severity (Tate *et al.*, 1989). Survivors with severe brain injuries may experience nearly no recreational activities. Tate and

colleagues (1989) found that over two-thirds (69%) of survivors ($n = 16$) had no social and recreational interests. The quality of life for the severe disability group was found to be further hindered by their inability to work. Severe brain trauma survivors were significantly different to a matched premorbid comparison group on measures of boredom, interests and hobbies (Weddell, Oddy, & Jenkins, 1980). A follow-up study found further deterioration in survivors' engagement of leisure activities over time (Oddy *et al.*, 1985). However, in spite of their extensive disengagement from a meaningful social life, most relatives claimed that survivors were content with their inactive lifestyle (Oddy *et al.*, 1985). Kersel and colleagues (2001) found 95% of survivors ($n = 62/65$) were socially active pre-injury but only 62% ($n = 40/65$) were reported to be so six months after injury onset.

1.6.4.3 Employment

Injury severity predicts the speed with which survivors return to work, if at all (Oddy, Humphrey, & Uttley, 1978). The likelihood of survivors with severe brain trauma resuming their former occupations is highly diminished (Weddell *et al.*, 1980; Kersel *et al.*, 2001). Even those who return to full time employment do so at a lower level (Weddell *et al.*, 1980; Tate *et al.*, 1989). The proportion of survivors returning to fulltime work has been reported to range from 44% to 55% (Weddell *et al.*, 1980; Klonoff *et al.*, 2006). Other authors have found that 71% of survivors receive government benefits (Kersel *et al.*, 2001). Kersel and colleagues (2001) found that only 8% returned to work and 85% were reliant on government benefits six months after injury onset, which contrasted with rates of 62% and 18%, respectively, pre-injury. Survivors who are able to work suffer from significantly less cognitive and personality disturbance than those who cannot (Weddell *et al.*, 1980). An additional consequence of being disengaged from a working life is that unemployed survivors face chronic social isolation and are less likely to achieve psychosocial reintegration (Oddy *et al.*, 1985; Tate *et al.*, 1989). Also the financial hardship that comes with the inability to work may detrimentally effect the self-esteem of survivors and their sense of identity (Tate *et al.*, 1989). Significant reductions in income and reliance on benefits are sources of anxiety and depression for both survivors and their families.

More recent studies examining psychosocial outcomes of survivors who have participated in positive rehabilitation programmes have reported more encouraging findings (Schalen, Hansson, Nordstrom, & Nordstrom, 1994; Klonoff *et al.*, 2006). These studies have illustrated the importance of effective neurorehabilitation following injury onset. Schelén and colleagues (1994) found that a substantial minority (30%) of the severe brain trauma survivors ($n = 106$) did not return to work or education and showed marked deficits in social and leisure

activities. The authors categorised survivors according to their period of treatment and whether they underwent an aggressive management protocol. The findings of the study suggested that favourable psychosocial and employment outcomes were related to improved rehabilitation. Encouraging findings were also reported by Klonoff and colleagues (2006). They found that 86% of survivors remained productive community members despite significant reductions in the proportion of those in work or education. Although the authors did concede the cohort may have been unrepresentative of the general brain injury population, as they were highly motivated and 96% worked or studied prior to injury. Nevertheless, the positive outcomes were attributed to the comprehensive rehabilitation received by the survivors. Rehabilitation was not considered in any of the aforementioned studies that documented far poorer return to work rates.

1.7 TREATMENT MODELS OF TRAUMATIC BRAIN INJURY

Various models of brain injury exist and each generates a particular therapeutic approach. The main treatment paradigms are based on the medical, cognitive and behavioural models. These treatment models will be covered in this section. Empirical findings supporting each theory driven rehabilitation approach will be discussed and evaluated. It shall be argued that behavioural models appear to be the most effective and relevant for traumatic brain injury survivors, who may exhibit severe cognitive, emotional and behavioural deficits.

Still, a conceptualisation of challenging behaviour derived from only one model of brain injury is incomplete. A unitary approach to rehabilitation, based on one model, supposes that challenging behaviour has a single aetiology. It is commonly believed, however, that the causal mechanisms of challenging behaviour are multiple and interdependent (Giles, 1999). The factors that influence the occurrence of challenging behaviours encompass physiological, individual and environmental aspects. There exists a biopsychosocial model that integrates medical, psychological and social models of treatment. It encompasses the complex interactions between biological, psychological and sociological factors of human functioning (Yeates, Gracey, & McGrath, 2008). The model includes personal, physical, social and temporal influences alongside pathology (Wade & de Jong, 2000; Wade, 2005). Originally, Engel (1977) formulated the model in a call for psychiatry to view the social context of mental illness as a key component. The biopsychosocial approach is now adopted in various fields (Borrell-Carrio, Suchman, & Epstein, 2004) and is central to a comprehensive patient care plan (Zimmerman & Tansella, 1996). A general descriptive framework of the approach is afforded in the World Health Organization's International Classification of Functioning,

Disability and Health (ICF) (2001). The ICF-model has been used as a template to derive other formal biopsychosocial models of illness (Wade & Halligan, 2003; 2004).

The practice of the biopsychosocial approach in neurorehabilitation provides a more complete understanding of acquired brain injury (Williams & Evans, 2003). The rehabilitation of disorders associated with acquired brain injury is designed from a biological, individual and social perspective (Wade, 2000; 2001; Dawson, Schwartz, Winocur, & Stuss, 2007). As such, this often involves a range of theoretical approaches in the implementation of neuropsychological interventions (Wilson, Rous, & Sopena, 2008). Consequently, a multidisciplinary approach that integrates various models is often adopted in clinical settings. This holistic practice has great therapeutic value because interventions, based on different treatment models, can be implemented both separately and in combination (Burke, 1995). With regard to challenging behaviour, there is evidence to suggest that a biopsychosocial approach to and model of aggression has clinical utility (Johansson, Jamora, Ruff, & Pack, 2008).

1.7.1 *The Medical Model*

The medical model conceptualises behavioural and emotional dysfunction as physiologically mediated and therefore amenable to biological treatment. The paradigm subscribes to a physical illness model of treatment and is prevalent in the United Kingdom and United States of America. Neurological physicians often head a team of health care professionals and influence the admission, treatment and discharge of traumatic brain injury survivors (Rose, 1999). The acute management of brain injury involves medical specialists managing survivors' care. This may involve surgical and pharmacological interventions that attempt to minimise damage and prevent secondary complications (Flannery & Buxton, 2001; Ghajar, 2000).

The medical model adopts a neuroanatomical approach to acquired brain injury. Cognition, emotion and behaviour changes are seen as the result of a change in neurobiological foundation (Jorge, 2005). Much knowledge has been gained from animal and neuroimaging studies of damaged and non-damaged brains (Silver *et al.*, 2005). Understanding of brain function has improved due to technological advances, such as functional imaging techniques. Nevertheless, actual resultant deficits do not necessarily match those predicted by the location of the damage. Cerebral functioning is complex and can be mediated by a variety of internal and external variables, which are idiosyncratic. Complex models of neuropsychiatry that incorporate environmental, genetic and neurological factors to

explicate neurological impairments and specific dysfunctional behaviours do not yet exist (Jorge, 2005).

There are no effective pharmacological treatments for brain injury (Kokiko, Murashov & Hoane, 2006). However, neurobehavioural problems that may arise following brain trauma have been treated pharmacologically. The rationale to this is that neurochemical changes or deficits are apparent in many psychiatric disorders in the non-brain-injured population. So, medication used to treat psychiatric disorders has also been used in the treatment of traumatic brain injury survivors who exhibit similar symptoms.

Empirically-based, randomised, double-blind, placebo drug trials have not been conducted with brain injury survivors and so the best treatments for specific behavioural disturbance are not known (Jorge, 2005). Consequently, treatment guidelines for the brain injury population are not available and medical approaches tend to be based on a trial-and-error approach derived from clinical experience (Silver, Arciniegas, & Yudofsky, 2005; Jorge, 2005).

There are difficulties associated with the accurate diagnosis of symptoms exhibited by brain injury survivors. Contemporary clinicians often propose pharmacological management as a last resort when psychologically-based therapies have failed. A 'start low, go slow' approach to the prescription of medication is advised (Silver *et al.*, 2005; Freeman *et al.*, 1999; Rose, 1999). Nonetheless, for a significant minority of survivors with severe impairments, behavioural and cognitive rehabilitation may be ineffective without any psychopharmacological intervention. Some survivors may pose a danger risk to themselves and others without medication (Silver *et al.*, 2005). Neurobehavioural disorders may cause significant distress to patients and their carers, as well as having an impact on the functional abilities of survivors. Therefore, medication can assist with patient management. Medications are often used to control behaviour or reduce agitation during the acute phase of recovery. Medication can significantly alleviate severe behaviour disorder that present a barrier to psychological treatment. Improvements have been demonstrated for delirium, agitation, depressed and psychotic states (Jorge, 2005). Improved cognitive skills in areas like attention and focus have also been reported following medication (Silver *et al.*, 2005). However, the validity of such support is limited as findings are mainly derived from small series or single case studies, which often lack any control or comparison groups (Silver *et al.*, 2005).

There are many other problems associated with medication generally and specifically in relation to the brain injury population. Brain-injured patients can be hypersensitive or under-reactive to medication (Rose, 1999; Silver *et al.*, 2005), which means that unusually small or large doses are required to ensure benefits become apparent. Under-reactivity can be problematic because high doses may impair function, inhibit recovery and aggravate

behaviours (Cantin, Gluck & McLean, 1992). Medication may also produce various adverse reactions, which can affect post-traumatic epilepsy, arousal, agitation, paranoia, dysphoria, irritability, impulsivity, delirium, motor slowing, memory, cognitive control, processing abilities, learning and performance (Johnson *et al.*, 1996; Freeman, 1999; Wilson and Dailey, 1999, Silver *et al.*, 2005). In addition, medication may have associated physical side effects, which brain trauma survivors seem to have an increased propensity to develop (Silver *et al.*, 2005). Discontinuation of particular medication can result in depression and fatigue (Silver *et al.*, 2005). As brain trauma survivors often exhibit a multiplicity of problems, a cocktail of medications (polytherapy) may be prescribed, which can result in toxicity. Polytherapy may increase adverse neuropsychiatric reactions. There are also issues regarding contra-indicative reactions, where one drug reduces the effectiveness of another (Silver *et al.*, 1999).

Pharmacological interventions appear to be more successful in treating positive neurobehavioural disorders and are less beneficial when applied to negative neurobehavioural disorders. However, medication is often prescribed for negative disorders to treat patients with apathy and affective disorders. It is recognised that neurobehavioural disorders are not independent from cognitive function or from the surrounding environment. This means that pharmacotherapeutic interventions are unlikely to be successful when used in isolation (Freeman, 1999). In practice, medication is used alongside cognitive and behavioural treatment approaches.

1.7.2 Cognitive Models

Cognitive deficits resulting from traumatic brain injury are recognised as underlying dysfunctional behaviours and reduced functional skills (Giles, 1999). Such deficits can be conceived as cognitive impairments and, from this perspective, treatment of neurobehavioural disorders can be delivered via interventions that focus upon cognitive remediation. This involves identifying previously efficient automatic cognitive processes that are damaged by the brain trauma and re-training them. It is held that if cognitive function can be improved then adaptive behaviours and functional skills will also improve.

There are two main cognitive approaches. The first attempts to restore reduced cognition and the other attempts to overcome or compensate for reduced function. Both approaches are used in clinical practice. However it is usual to only employ compensatory techniques once underlying cognitive skills have improved. Repeated learning in different situations will assist patients in seeing task similarities across different situations, thereby generalising (Gordon *et al.*, 1992). Restorative efforts may assist the ability to adopt

compensatory strategies, which in turn may help restore normal cognition (Ylvisaker, 1998, cited in Carney *et al.*, 1999).

1.7.2.1 Restorative Approaches

Process specific restorative approaches are driven by cognitive neuroscience. Restorative approaches attempt to improve cognitive abilities by restoring impaired cognitive abilities through repetitive exercise. The underlying rationale is that distinct cognitive domains can be separately influenced. This is achieved by stimulating the underlying processes of a specific cognitive skill set by means of a hierarchical bottom-up model. The contention is that basic cognitive components must be retrained before attempting more complex cognitive components or functional skills training (Solhberg & Mateer, 1987). The distinct components involved in a cognitive process are identified and addressed sequentially through the practice and repetition of cognitive tasks. The tasks increase in complexity and require additional processing abilities once simpler skills are mastered. Performance feedback is given to patients and their effectiveness is evaluated.

Restorative approaches are often implemented by using computer programmes. Basic cognitive skills can be stimulated by playing games that set tasks to improve perception, attention and memory. The benefits of such technologies are that patients receive accurate feedback on performance immediately and that improvement can be monitored efficiently (Giles, 1999). However reliance on computer trials to implement skill training may limit its efficacy. The absence of human interaction and feedback may cause patients to feel such exercises are disassociated from any real life relevance, thereby hindering their motivation to engage in the approach (Gordon & Hibbard, 1992, cited in Gordon & Hibbard, 2005). In fact controlled trials have shown that using computers is neither more nor less effective than non-computer based methods (Cicerone *et al.*, 2000). Moreover, those with significant physical and cognitive impairments may be unable to use a computer anyway.

Competent attention abilities are viewed as a prerequisite for the instigation of remediation for other cognitive deficits, such as perceptual and memory (Gordon *et al.*, 1992). Hierarchical skill building is utilised similarly across all these cognitive domains. Solhberg and Mateer (1987) taught progressively more complicated levels of attention, in terms of task complexity, once simpler components were attained. Mild to moderate sustained and selective attention deficits improved to within normal limits and severe attention deficits increased to the mildly impaired range. Although the authors concede that attention skills were not solely responsible, these improvements were associated with increased functional skills.

Giles (1999) has argued that any gains made by survivors with severe brain trauma are task specific and do not generalise to related activities or novel situations. Ylvisaker and colleagues (2002) have supported this position by claiming that cognitive test performance may differ to cognitive performance in daily situations. There is no evidence to support the notion that practised skills result in a generalised improvement for that cognitive domain or that improvements have even occurred in the underlying process (Giles, 1999). These critical arguments are strengthened by the findings of a review of attention training studies, which did not find any support that process-specific approaches improved functional abilities (Park & Ingles, 2001). The review examined 26 process-specific studies that mostly used participants who were survivors of severe traumatic brain injury. It was found that overall attention retraining did not significantly improve outcome. Also, those studies that did report a statistical significant outcome did not adopt any control measures. Learning did not generalise to tasks dissimilar to the skill being trained, even if it required the same underlying process.

1.7.2.2 *Compensatory Approaches*

The focus of cognitive approaches has been increasingly shifting away from improving specific cognitive processes through repetition. More emphasis has been placed upon developing strategic thinking within functional domains (Ylvisaker, Hanks, & Johnson-Greene, 2002). A top-down model is often applied in which dysfunctional behaviours are avoided and replaced by changing how cognitive skills are used. Compensatory processes can be encouraged and generated through improved metacognition. For example, a metacognitive model developed by Naren and Narens (1994, cited in Giles, 1999) asserts that neurological damage causes impairment at the meta level model of how cognitive skills operate and so patients are unaware of their impaired cognitive skills. This causes an inability to compensate for cognitive deficits. It is argued that the aim of cognitive therapy should be to readjust the metacognitive model by increasing awareness and problem solving skills. Consequently this facilitates patients to change the metacognitive model of the self and adopt new regulatory behaviours.

A variety of techniques have been used to encourage adaptive compensatory skills, in order to overcome impairments. These strategies may be external or internal. External strategies may include the use of diaries, calendars, wall charts and lists to help improve poor memory. Alternatively memory may be improved by using internal strategies such as self-regulatory techniques (self-talk) and mnemonic techniques, like visual imagery. However these strategies necessitate a required level of attention and learning abilities, which are often absent in the brain injury population. Giles (1999) has argued that internal strategies are

difficult, demanding and time consuming for those with severe cognitive impairments. Motivation to learn these techniques may be poor because the additional mental effort required may outweigh perceived benefits, especially as the techniques may appear irrelevant to real life activities. Moreover the strategies may be difficult to retain for patients with poor memory, which means that they may not be able to remember when and how to apply these skills. It is recognised that the skills learned through such techniques may not be maintained (Gordon *et al.*, 2005). Also compensatory approaches require the long term use of strategies that patients may choose not to persist with. Engagement in rehabilitation will be poor if individuals are not willing or motivated to participate (Van der Broek, 1995).

A systematic review conducted by Carney and colleagues (1999) found that external strategies were more effective at improving everyday memory for brain trauma survivors. However, those individuals who are able to learn how to programme the aid devices may either forget to use them or use them haphazardly (Wade & Troy, 2001). These problems may be overcome by externally programmed electronic reminders, which prompt initiation of internal and external strategies. However, visual, perceptual and language difficulties may make instructions difficult to read. Individuals may not even use compensatory aides because they can be regarded as cumbersome and embarrassing to use in public (Van der Broek, 2005). Wade and Troy (2001) attempted to overcome these barriers by developing a reminder service via mobile phones. This mode was deemed particularly appealing to young males who are overrepresented in the traumatic brain injury population. The use of mobile phones allows messages to be fed back to caregivers thereby providing a means of monitoring how effectively the aid is used. The aid was found to promote many self-initiated behaviours, such as taking medication, self care and attending appointments. This model may be increasingly important as the telecommunication technology continues to develop.

The effectiveness of cognitive rehabilitation approaches has not been fully evaluated because of an insufficient number of large scale outcome studies (Gordon *et al.*, 1992). Most of the outcome studies conducted lack rigour due to the small numbers of participants involved. Cicerone and colleagues (2000) conducted a systematic review of 171 studies of various cognitive rehabilitative approaches. It was found that the majority (63%) of articles were single case studies or clinical series without any controls. Only 20% were prospective cohort studies, retrospective case-control studies or clinical series with controls, which are more methodologically vigorous. Randomised controlled trials were only adopted in 17% of studies. The authors concluded cognitive approaches improved attention, memory, communication and executive functioning for brain trauma survivors. Carney and colleagues (1999) conducted another systematic review of 32 studies relating to cognitive remediation

with the brain injury population. The main area of investigation in the review concerned whether rehabilitative efforts translated to improvement in daily functioning as opposed to merely improving cognitive test performance. It was found that interpersonal relationships, self concept, memory and anxiety were improved by compensatory techniques and that cognitive deficits as measured by laboratory tests also improved. However, there was no significant evidence to suggest that such improvements led to real life improvements in terms of functional outcome. The authors criticised the body of research examined for implementing interventions and using outcome measures that lack ecological validity and relevance to brain trauma survivors.

Gordon and Hibbard (1992) have stated that any lack of success as measured by patients' ability to generalise training to functional abilities does not necessarily mean that cognitive remediation is inappropriate. The authors propose that patients be taught the mechanisms underlying their cognitive deficits and how they directly impact upon functional abilities. It has been claimed that doing this will encourage problem anticipation and solving strategies required for generalisation effects to occur. The proposal requires an individualised approach that suits the interests of each patient. Cognitive task materials that gradually approximate to real life activities should be devised so that they relate directly to daily functioning. Likewise, Van der Broek (1995) has advocated a client centred approach, where treatment addresses the problems that the patient wishes to overcome, as opposed to those determined by the clinician on the basis of cognitive test performance. It is recognised that clinical goals and patients goals may differ. Patients may not be ready to address their problems due to reduced insight and emotional disengagement that results from their cognitive and neurobehavioural deficits. Typically, levels of motivation, interest and commitment are low for this group (Campbell & Tyerman, 2000). It has been recognised that these may have a negative impact upon the therapeutic relationship. To overcome these barriers, insight must be raised to facilitate compliance (Van der Broek, 1995).

1.7.2.3 *Cognitive Psychotherapy*

Cognitive psychotherapy is needed to help patients gain an insight into their cognitive limitations and how these impact upon their daily life (Gordon *et al.*, 2005). Cognitive psychotherapy facilitates patients to acknowledge and accept their losses and subsequently to integrate a realistic view of their abilities. Any psychotherapy conducted must take account of the limitations of patients, given that most will exhibit difficulties with abstract thinking, memory, executive function, insight and reduced processing speed. The approach enables patients to process, integrate, accept and understand the need to relearn

skills and adopt compensatory strategies (Gordon *et al.*, 1992). Also it permits patients to deal with interpersonal issues as manifested through any dysfunctional behaviours. Cicerone and colleagues (2000) found that a combination of cognitive psychotherapy and remediation approaches were successful in significantly reducing cognitive and psychosocial disabilities. However, such integrative approaches are long-term and costly, and so may not be possible in many rehabilitative settings (Gordon *et al.*, 1992; 2005).

The process of psychotherapy in light of the cognitive limitations of brain trauma survivors may take years. Willingness and ability to engage in this long therapeutic process may be hindered by behavioural problems, such as apathy, depression, disinhibition and aggression. Any reluctance to engage fully with cognitive psychotherapy impacts upon treatment success. Also, as the approach is a verbally based treatment and so requires a high level of receptive and expressive language skills (Willner, 2006). This means that a cognitive psychotherapeutic approach may be inappropriate for brain trauma survivors with severe cognitive and behavioural deficits.

1.7.3 Behavioural Model

Behavioural models are founded on the premise of determinism, which states that all behaviours are orderly and predictable (Yody *et al.*, 2000). Behavioural treatments seek to modify and manage maladaptive behaviours predominantly by means of operant conditioning. The underlying tenant of operant conditioning is that the likelihood of a response being emitted within a given environmental context is affected by its consequences. The mechanism of behaviour change is associative learning. It may seem counterintuitive that conditioning methods may be used with brain injury survivors who have organic deficits that cause memory impairments. However, it has been well documented that other populations with impaired learning abilities, such as those with intellectual and developmental disabilities, have benefited from the behavioural treatment methodologies (Emerson, 2001). The challenging behaviours exhibited by these population groups are similar in form and nature to those witnessed in the brain injury population.

The behavioural model focuses direct on observable behaviours only. It seeks to change dysfunctional behaviours and promote functional skills without regard for any underlying neurophysiological or cognitive deficiencies. The model adopts a hierarchical approach that seeks to establish new functional behaviours and skills once more simple ones have been learned. This is achieved through techniques such as shaping, chaining, fading, prompting and behavioural skills training (Miltenberger, 2000). The behavioural perspective

provides a coherent, measurable and scientific approach to the evaluation and treatment of traumatic brain injury (Giles, 1999).

The basic principles of operant conditioning are briefly explained below (see, Miltenberger, 2000). If a response is repeatedly followed by a reward then the likelihood of the response occurring again in the future increases. This process of reinforcement strengthens the response. Reinforcement becomes operative either by the presentation of a preferred stimulus (positive reinforcement) or the removal of an aversive stimulus (negative reinforcement). Conversely, if a response is repeatedly followed by an aversive stimulus then the likelihood of the response occurring again in the future decreases. This process weakens the response. Punishment becomes operative either by the presentation of an aversive stimulus (positive punishment) or the removal of a preferred stimulus (negative punishment). Another basic principle of operant conditioning is extinction. Extinction is the process of weakening previously reinforced behaviour by terminating its reinforcing consequences. The procedure of extinction either involves withholding the reinforcer for positively reinforced behaviours or no longer removing the aversive stimulus for negatively reinforced behaviours.

Most neurobehavioural treatments involve the application of procedures based on punishment, reinforcement and extinction principles. Differential reinforcement may be implemented to increase the frequency or duration of appropriate behaviours and extinction procedures used to weaken maladaptive operants. There are a number of procedural variants of the differential reinforcement procedure. Differential reinforcement of other behaviours (DRO) is commonly implemented with survivors who emit a very low frequency of adaptive behaviours and a very high frequency of maladaptive behaviours. A DRO procedure involves presenting reinforcement after a period of time in which the maladaptive behaviour does not occur (McMillan, Papadopoulos, Cornall, & Greenwood, 1990; Davis, Turner, Rolider, & Cartwright, 1994). Differential reinforcement of an alternative behaviour (DRA) involves reinforcement of a specified behaviour that is functionally similar to the problem behaviour. The specific behaviour targeted for reinforcement may be an adaptive communicative response. The communication response may be taught using either manual signing (Horner & Day, 1991), picture communication symbols (Kahng, Hendrickson, & Vu, 2000) or assistive communicative devices (Durand, 1999). Such functional communication training techniques have been effective in producing behaviour change in survivors of traumatic brain injury (Treadwell & Page, 1996; Rothwell, LaVigna, & Willis, 1999; Fyffe, Kahng, Fittro, & Russell, 2004). Differential reinforcement of an incompatible behaviour (DRI), which means that both behaviours cannot occur simultaneously, has been applied successfully in the brain injury literature (Mozzoni & Hartnedy, 2000; Dixon *et al.*, 2004). Finally, the procedure of

differential reinforcement of low rates of responding (DRL) involves the delivery of reinforcement contingent on the presence of the maladaptive behaviour but only when rates of the response fall below a stipulated level. Such procedures can be used when a certain level of responding can be tolerated (Alderman & Knight, 1997a; 1997b; Alderman, 2003).

Reinforcement can be delivered using a token economy system (Wood, 1984; Wood *et al.*, 1988). Token economies deliver reinforcement via secondary reinforcers, like money, tokens or stars. Such conditioned reinforcers have no inherent reinforcing properties. They become established as reinforcers through their association with a primary reinforcer. Often feedback is used to help survivors discriminate those responses that are being reinforced (Giles *et al.*, 1993). Token economies have been adopted effectively in neurorehabilitation settings (Manchester, Hodgkinson, Pfaff, & Nguyen, 1997; Guercio & McMorrow, 2002). Often the procedure can be incorporated with a response cost technique. Response cost is a punishment technique that involves withholding or removing the reinforcer contingent on maladaptive behaviours. This procedure has been used successfully with traumatic brain injury survivors (Manchester, Hodgkinson, & Casey, 1997; Mottram & Berger-Gross, 2004).

In addition to response cost, other punishment procedures have also been used with the brain injury population. Time-out (from positive reinforcement) is a procedure that involves removing access to positive reinforcers for a period of time contingent on maladaptive behaviour. Two procedural variations of time-out exist. Exclusionary time-out involves physical relocation of the individual from the reinforcing environment (Andrewes, 1989; Alderman, 1991). Non-exclusionary time-out involves terminating access to the reinforcer without relocating the individual (Peters, Gluck, & McCormick, 1992). Time-out and response cost procedures are based on negative punishment. Positive punishment procedures, which involve the delivery of an aversive stimulus contingent on maladaptive behaviours, are contentious and have ethical implications. The most commonly used aversive stimuli are guided compliance (Alderman, Davies, Jones, & McDonnell, 1999) and physical restraint (Persel, Persel, Ashley, & Krych, 1997).

All the processes described above are behaviour modification procedures, which seek to change learned behaviours by responding in ways that alter the likelihood of recurrence. In contrast to such reactive approaches, action may be taken to prevent the occurrence of challenging behaviours by managing the antecedent conditions that may occasion them. Behaviour management techniques involve altering the environment to avoid maladaptive behaviours from taking place. This proactive approach, in which the onus of responsibility rests with caregivers, is commonly known as positive behaviour support (Johnston, Foxx, Jacobson, Green, & Mulick, 2006). Its primary focus is to control antecedents. The techniques

used may include adjusting task difficulty to facilitate success, facilitating behavioural momentum for difficult tasks, offering patients choice regarding aspects of their daily routine, providing natural rewards for positive behaviours and communicating in a supportive manner at all times (Ylvisaker *et al.*, 2007). Antecedent control procedures have been successfully implemented in neurorehabilitation settings (Schlund & Pace, 1999; Hartnedy & Mozzoni, 2000; Fluharty & Glassman, 2001; Pace, Dunn, Luiselli, Cochran, & Skowron, 2005). Specific techniques like behavioural momentum (Treadwell *et al.*, 1996), feedback after inappropriate behaviours (Ebanks & Fisher, 2003), earned escape (Slifer *et al.*, 1997) and noncontingent reinforcement (Persel *et al.*, 1997; Yody *et al.*, 2000; Pace *et al.*, 2005) have been implemented with brain injury survivors.

In addition to behaviour modification and antecedent control procedures, behavioural interventions can also be used in conjunction with cognitive therapies. The appropriateness of the behavioural intervention reflects the functional abilities of the brain injury survivor. Survivors with a greater severity of brain injury are more likely to require interventions that manage the presentation of antecedents (Giles, 1999). Whereas cognitive behaviour therapies may only be appropriate for those with mild brain injuries (Wilson *et al.*, 1999). Learning-based models of intervention are especially applicable to brain trauma survivors with moderate to severe injuries (Wood *et al.*, 1988). Behavioural interventions based on operant conditioning have been shown to be effective for reducing a variety of challenging behaviours and promoting functional skills for brain trauma survivors. The efficacy of these interventions has been demonstrated even during the acute stages of brain injury recovery (Slifer, Cataldo, & Kurtz, 1995).

1.8 SUMMARY

Traumatic brain injury is a major health issue and a leading cause of death and disability. The high risk groups are children, young adults, males and those from lower socioeconomic positions. Survivors of brain trauma may require a multitude of rehabilitative services for the remainder of their lives. Prognosis following a traumatic brain injury varies. The best single predictor of short-term outcome is the severity of neurological damage. However, even mild brain injuries can result in persistent and significant problems. All survivors of traumatic brain injury may experience physical, cognitive and psychosocial impairments. Of the neurobehavioural sequelae of traumatic brain injury, challenging behaviours can be the most problematic. Aggression, self-injury and inappropriate sexual behaviours are particularly distressing for the relatives and caregivers of survivors. Challenging behaviours may also present a serious barrier to the successful administration of

rehabilitative therapy. The occurrence of challenging behaviours can be chronic. This problem is exacerbated by the tendency for the severity of challenging behaviours to increase with time. This is especially the case for survivors with severe brain injuries.

The medical model conceptualises neurobehavioural disorders as physiologically mediated and therefore amenable to biological treatments. Challenging behaviours are treated pharmacologically within this dominant paradigm. However, pharmacological interventions, designed to sedate brain trauma survivors, only temporarily succeed in partially suppressing challenging behaviours. Nevertheless, medication is commonly used in spite of very limited evidence of its effectiveness with the brain injury population. Survivors of traumatic brain injury are often either hypersensitive or under-reactive to medication. Consequently, they may be especially prone to suffer from the side-effects of medication, which may actually engender aggressive forms of challenging behaviour. Moreover, brain trauma survivors are usually prescribed a cocktail of medications because they exhibit numerous neurobehavioural problems. Such polytherapies may result in toxicity and an increased likelihood of adverse neuropsychiatric reactions. The evidence suggests that pharmacotherapeutic interventions with brain injury survivors are unlikely to be successful when used in isolation. Neuropsychiatry may only bring benefit when used alongside other treatment approaches.

Neurobehavioural disorders can also be conceptualised as being mediated by cognitive deficits. Cognitive approaches to treatment focus on cognitive remediation and seek either to restore or compensate for impaired cognitive functioning. Restorative intervention techniques aim to improve specific cognitive skills through repetition by using computer trials. However, this reliance on computer programmes to implement skills training may not be appropriate for all traumatic brain injury survivors. Survivors with moderate or severe injuries may lack the physical and/or cognitive abilities even to use the technology. Furthermore, the electronic medium may cause survivors to feel the exercises lack any real life relevance. Compensatory techniques use a variety of strategies to promote adaptive compensatory skills. These may include external strategies to help improve poor memory, like diaries, calendars, wall charts and lists, and internal strategies, like self-regulation (self-talk) and mnemonic techniques such as visual imagery. However, the use of these strategies necessitates a certain level of attention and learning ability in the first place. These are often absent in the brain injury population, especially amongst survivors with moderate to severe injuries. Moreover, those with moderate to severe injuries may present challenging behaviours that preclude them from engaging in cognitive interventions anyway. The evidence suggests that treatment gains using cognitive approaches are task specific and do not generalise to related activities or lead to real life improvements in terms of functional outcomes.

Interventions based on the behavioural model are suitable for all brain trauma survivors irrespective of the severity of their injury. Behavioural-based treatments seek to manage and modify challenging behaviours by means of operant conditioning. The behavioural model is the most appropriate approach for treating all forms of challenging behaviours. Its effectiveness has been well documented with the traumatic brain injury population and also other populations, such as intellectual and developmental disabilities. Associative learning techniques can be used to not only reduce challenging behaviours but also to promote functional skills. Moreover, reinforcement procedures can be applied to teach adaptive alternatives to challenging behaviours that are functionally equivalent. Functional communication training is especially pertinent for traumatic brain injury survivors who often suffer communicative difficulties. Behaviour modification procedures can be tailored according to the severity of brain injury. Survivors with severe brain injuries may benefit more from interventions that prevent challenging behaviours by managing the presentation of antecedent conditions. Whereas cognitive-behaviour therapies may be appropriate only for those with mild brain injuries. Learning-based models of intervention are especially applicable to brain trauma survivors with moderate to severe injuries.

In order for behavioural intervention techniques to be implemented effectively, the influence of the environment on the occurrence of challenging behaviours must be appraised. An assessment is needed to establish the extent to which challenging behaviours are under the control of social contingencies, such as the removal or presentation of attention or task demands. This identification of the purpose or 'function' of challenging behaviours is crucial. Learning-based interventions can then be designed according to the social contingencies that influence challenging behaviours. Otherwise, behavioural techniques that are implemented on an incorrect assumption of function may actually increase the occurrence of challenging behaviour. So, an accurate assessment of behavioural function is needed to ensure that proposed interventions are appropriate to the target behaviour. Chapter 2 shall describe the various functional assessment methods that can be used. The strengths and limitations of these methods will be outlined.

CHAPTER 2 FUNCTIONAL BEHAVIOURAL ASSESSMENTS

2.1 APPLIED BEHAVIOUR ANALYSIS

An introduction to traumatic brain injury and its consequences was provided in Chapter 1. One problem that commonly arises following brain trauma is the presentation of challenging behaviours. Challenging behaviours are significant obstacles to achieving successful rehabilitative outcomes. It was stated that the neurobehavioural rehabilitation of challenging behaviours may involve the use of medication, cognitive remediation and/or behavioural modification techniques. These treatment models were analysed and it was claimed that the behavioural model has the strongest empirical support.

The operant behavioural hypothesis is that challenging behaviours are learned behaviours that are precipitated by environmental stimuli and maintained by their consequences. In this sense, challenging behaviours are seen as functional and adaptive. As such, behaviour modification involves the use of intervention procedures that are based on punishment, reinforcement and extinction principles. The rate of challenging behaviour may be reduced by using these techniques to modify existing contingencies or introduce new contingencies. In order to do this effectively, behaviour interventions should account for the environmental causes of the challenging behaviour or the variables that maintain it. If an implemented behavioural intervention is incongruent with the function of the challenging behaviour then the occurrence rate of the challenging behaviour may actually increase.

Applied behaviour analysis is a discipline that seeks to apply principles of operant conditioning to the solution of various problems of social significance. It has contributed significantly in bringing about positive and durable changes in the behaviours of those with autism, developmental disorders and intellectual disabilities (Emerson, 2001). However, the neurorehabilitation field has been slow to embrace the practice (Mozzoni, 2000), despite strong calls for the management of brain injury to be driven by an integrated model of applied behaviour analysis (Yody *et al.*, 2000). An applied behaviour analytic approach seeks to demonstrate that changes in challenging behaviours are linked to social variables. This is done by measuring and analysing challenging behaviours using functional behavioural assessments.

The aim of this chapter is to review the research literature regarding functional assessments. The focus of the review will be on describing and identifying features of various functional assessment methods. The strengths and limitations of the different functional assessment methodologies will be related in terms of both theoretical and practical significance. In the last section of the chapter, the functional assessment methods that have

been used with the brain injury population will be listed. Then a critique will be provided of the only standardised functional assessment tool designed specifically for survivors of acquired brain injury.

2.2 FUNCTIONAL ASSESSMENT METHODS

2.2.1 Introduction

The relationship between challenging behaviours and environmental events can be investigated using many different methods. The methods of identifying behavioural function can be categorised in various ways. One way is to group assessment methods by their data collection procedure. Procedures for collecting data vary along the dimensions of time and place (Durand, 1990). The collection of data is either live or retrospective (time) and it occurs in either an intact or modified environment (place). As such, methods of assessment can be listed within a 2×2 table. However, the distinction between the two retrospective categories is somewhat obscure. Consequently, it is far more usual to consider functional assessment methods using a three category system. These three categories often are named differently by different authors. Despite the contrast in terminology, reference is made to the same categorisation system for functional assessment methods. Crawford, Brockel, Schauss and Miltenberger (1992) divide assessment methods into three categories: (a) informant assessments; (b) direct observation; and, (c) functional or experimental analysis. Hall (2005) refers to: (a) informant-based assessment; (b) descriptive assessment; and, (c) experimental assessment. Others make reference to the three strategies for collecting functional assessment data: (a) interviews; (b) direct observation; and, (c) systematic manipulations (O'Neill *et al.*, 1997). The most commonly used terms are: (a) indirect assessment; (b) descriptive analysis; and, (c) functional analysis (Iwata, Vollmer, Zarcone, & Rodgers, 1993).

An indirect assessment is an informant-based measure of behaviour provided retrospectively by caregivers. The strategies used to collect such data are behavioural interviews, questionnaires or rating scales. Informant assessments are administered efficiently and are an intuitive way to infer behavioural function. A more direct approach to functional assessment is one that uses live observation techniques. Direct observation involves recording the frequency of behaviours and their relationship with social stimuli. This descriptive analysis yields correlational data and can be used to form hypotheses about behavioural function. Experimental functional analytic procedures test these hypotheses by appraising the extent to which behaviour is controlled by hypothesised environmental events. This involves presenting various social stimuli in a standardised manner and measuring their effect on the

frequency of behaviour. These manipulations of environmental variables take place in a modified setting that is created to be analogous to the natural environment.

Durand (1990) used the term ‘hierarchy’ to refer to the increasing scientific rigour of each successive assessment method. However any advancement in methodological sophistication has an associated practical cost. Procedural accuracy and robustness requires more time and resources. This balance between precision and efficiency means no assessment method can be hailed as perfect. All assessment tools have particular strengths and limitations, and so different methods will be recommended in different situations. In clinical settings concerns for efficiency will drive the selection of assessment strategy. Whereas published research requires precision and so formal functional analysis is expected (Horner, 1994). The term ‘hierarchy’ also implies that functional assessment methods build on each other. In this sense, a hierarchical model of functional assessment is a process that requires the collaboration of successive assessment methods. If consecutive procedures produce converging results then an intervention program can be implemented confidently. Functional assessment then refers to the full range of strategies employed to determine the environmental events that control aberrant behaviour.

Functional assessment is the process of collecting information, using different procedures, in order to develop and test hypotheses about the function of behaviour. A complete functional assessment is a system that involves various stages of assessment. Some authors have viewed functional assessments in terms of distinct stages. Emerson (2001) set out four stages necessary to conduct a full functional assessment: (a) identification and definition of the challenging behaviours targeted for intervention; (b) description of the relationship between the challenging behaviours and environmental events; (c) generation of hypotheses concerning the maintaining contingencies of the challenging behaviours and the nature of variables which set the occasion for them to occur; and, (d) testing of these hypotheses prior to intervention. Omitting the preliminary stage of determining the target behaviour, the stages outlined in Emerson (2001) correspond closely with those of other authors. Carr and colleagues (1994) refer to assessment strategies in terms of three stages: (a) description; (b) categorisation; and, (c) verification. Cone (1997) describes three phases of the functional approach: (a) the descriptive phase; (b) the interpretative phase; and, (c) the verification phase. All essentially refer to the same stages in the process of a comprehensive functional assessment methodology.

2.2.2 *Indirect Assessment Methods*

Indirect methods of functional assessment are informant-based measures. Caregivers who are well acquainted with the client provide information about the controlling variables of challenging behaviours. This information can be gathered using various techniques such as clinical intuition, structured interviews, questionnaires or rating scales. These assessment techniques require relatively little training and administration time. Their ease of use means they are applicable for large group studies. The small costs associated with indirect methods make them an efficient method for the assessment of infrequent challenging behaviours. Often indirect assessments method are the only means of evaluating some types of challenging behaviour. Behaviours that must be reduced due to ethical considerations lend themselves only to indirect forms of assessment. For instance, severe self-injury or sexual assaults cannot be allowed to occur freely and so are not amenable to direct behavioural observational methods (Thompson, Symons, & Felce, 2000).

Also, the information provided is comprehensive and accounts for a wide range of environmental variables. However, the data collected is retrospective, which can be biased by inaccurate recollections or misperceptions. Furthermore, the reliability and validity of indirect methods varies and can be poor. Overall indirect assessment methods lack the objectivity and empiricism of other more rigorous functional assessment methods. Indirect assessment methods should be used as a prelude to a more complete functional assessment process. The information yielded by indirect assessment methods should be used in conjunction with other methods, to direct subsequent stages in the functional assessment process (Millard *et al.*, 1993; Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001).

2.2.2.1 *Clinical Intuition*

In clinical settings, often clinical intuition is used to identify the maintaining variables of challenging behaviour. Clinical intuition is the subjective judgement of causality. The causal hypotheses proposed though are biased because intuition is likely to reflect clinical knowledge, training and experience. As such clinical intuition has been viewed as a form of guessing (Durand, 1990). Nevertheless some have regarded intuition as an invaluable part of the clinical decision making process (Haynes, Spain, & Oliveira, 1993). It is often expressed in multidisciplinary team meetings and can assess a large range of social stimuli swiftly. However, clinical intuition is not strictly a functional assessment method since it is not based on measurement, any form of systematic recollection or empirical documentation.

2.2.2.2 *Functional Assessment Interviews*

Interviewing is a common technique used in various clinical settings to gather information about clients. Many standardised clinical interviews are available to classify various psychological disorders. A functional assessment interview is a specific type of clinical questioning that seeks to determine the function of challenging behaviour. The aims of the functional assessment interview are to provide a comprehensive account of the challenging behaviour, the situations in which it occurs and the environmental variables which maintain it. These goals are the same as the functional assessment process as a whole. Diagnostic interviewing generally requires self-report (Sher & Trull, 1996). Clearly this type of interviewing is not applicable for those with limited self insight or communication abilities. In such cases information has to be collected from a third party who is well acquainted with the client. The third party interviewee could be the patient's therapist, care provider, parent or teacher. Functional assessment interviews are administered to a third party respondent.

O'Neill and colleagues (1997) have described some topics that should be covered in a functional assessment interview. Information should be gathered about all problem behaviours exhibited by the client and not limited to just the most severe ones. An operational description of behaviours should include details regarding topography, frequency, duration, severity and impact. Also the extent to which particular behaviours occur concurrently or in sequence is an important aspect of describing behaviour. Information regarding aspects of the client's environment or daily schedule that may influence the occurrence or non-occurrence of the target behaviour should be sought. Such setting events may include, for instance, medication, physiological discomfort, sleeping cycles, eating routines or staffing patterns. Information about the social circumstances and events surrounding the challenging behaviour should be gathered. The interview should establish the activities, schedules, people or situations that may predict the occurrence of the target behaviour. Also the consequences of the challenging behaviour would be needed to establish its function. Other areas of relevance in a behavioural interview may include the efficiency of the target behaviour, any alternative functionally equivalent behaviours, the client's communicative strategies, outcomes of previous intervention attempts and informal strategies used by staff to prevent the occurrence of challenging behaviour. Day and colleagues (1994) advised that a wide range of information be considered when using indirect assessment procedures.

Functional assessment interviews usually adopt a structured format (e.g., Bailey & Pyles, 1989; Tanaka-Matsumi, Seiden, & Lam, 1996; O'Neill *et al.*, 1997). Structured interviewing involves the interviewer methodically asking standardised questions on prearranged topics. Compared to less formal questioning, a structured interview format

minimises context effects and the chance of omitting important discussion topics. A structured interview may contain closed questions throughout. In which case the interviewer essentially is reading a questionnaire to the informant and records the responses. However, a semi-structured interview offers more scope for dialogue-led information and provides a more individualised behavioural assessment. Both structured and semi-structured behavioural interviews are convenient for use in a clinical setting. They require little training to administer and are quick to conduct. An interview with two informants may take between 45 and 90 minutes (O'Neill *et al.*, 1997). Clinicians may construct their own interview protocol. Alternatively standardised functional assessment interviews are available to use. These include the Functional Assessment Interview (O'Neill *et al.*, 1997) and the Culturally Informed Functional Assessment Interview (Tanaka-Matsumi *et al.*, 1996). All functional assessment interviews have unknown reliability and validity. No studies to date have investigated their psychometric properties. Given the limitations of indirect retrospective measures, behavioural interviews should be used in conjunction with other functional assessment methods.

2.2.2.3 *Rating Scales*

Rating scales are another indirect method of functional assessment. A rating scale is a type of questionnaire where informants indicate a number on a scale, using a Likert-type scale, which best describes the extent or intensity of the item being measured. This section will cover in depth two rating scales that have been developed to assess the function of problem behaviour: the Motivation Assessment Scale (Durand & Crimmins, 1988; 1992) and the Questions About Behavioral Function (Matson & Vollmer, 1995; 2000). Both rating scales are administered in an interview format to a caregiver who is well acquainted with the client. As with other informant-based measures, rating scales require relatively little training and administration time. Also, the information provided is retrospective and so rating scales can be biased by inaccurate recollections or misperceptions. So rating scales should be used in conjunction with other functional assessment methods.

2.2.2.3.1 Motivation Assessment Scale

Devised by Durand and Crimmins (1988; 1992), the Motivation Assessment Scale (MAS) is a rating scale that aims to identify the causal and maintaining variables of challenging behaviour. The MAS was the first functional assessment checklist to appear in the applied behaviour analytic literature (Matson & Minshawi, 2006). It has been the most extensively evaluated psychometric instrument developed for functional assessment (Sturme, 1994). The scale was designed initially to assess the function of self-injurious behaviour in

children with developmental disabilities. However, it has been adopted as a behaviour checklist for other topographies of challenging behaviour and population groups (Durand, Crimmins, Caulfield, & Taylor, 1989). The MAS is a sixteen-item questionnaire made up of four sets of four questions. Each set of questions relates to a distinct functional category involved in maintaining challenging behaviour. These four categories of reinforcement are: (a) positive reinforcement in the form of attention; (b) positive reinforcement in the form of tangible items; (c) negative reinforcement in the form of escape from aversive stimuli; and, (d) automatic sensory reinforcement. The relative influence of each type of reinforcement is measured by the MAS. Informants are required to rate the likelihood of the target behaviour occurring under various circumstances. The responses are recorded along a 7-point Likert scale, ranging from 'never' to 'always'. High scores implicate the variable as potentially influential. A mean score is calculated for each reinforcement category, by taking the average of the four subscale items, to assess the comparative control of each function.

The creators of the scale have claimed that the MAS is a reliable and stable instrument with great predictive value (Durand & Crimmins, 1988; Durand *et al.*, 1989; Durand, 1999). Durand and Crimmins (1988) measured concordance between graduate teachers and classroom assistants in their assessment of fifty developmentally delayed children who exhibited frequent acts of self-injury. Inter-rater reliability was measured in terms of: (a) individual questionnaire items; (b) mean scores for each reinforcement category; and, (c) the ranked ordering of the four reinforcement categories. The authors reported robust levels ($p < .001$) for all the correlational analyses conducted. Pearson product-moment correlation coefficients (r) for the item scores and the mean scores ranged from .66 to .92 and from .80 to .95, respectively. The Spearman's rank-order correlation coefficient (ρ) for the ranked category scores ranged from .66 to .81. Test-retest reliability was measured similarly by administering the MAS to the primary raters again after 30 days. Correlations for the item scores, mean scores and ranked category scores ranged from .89 to .98, from .92 to .98 and from .82 to .99, respectively. The predictive validity of the MAS was assessed by comparing its results with those derived from an experimental functional analysis. The analogue conditions were an adapted version of those used by Carr and Durand (1985) (see section 2.2.4.1). The validation study reported that 100% of participants exhibited a greater rate of self-injury during the expected analogue condition. The rank ordering of reinforcement categories derived from both the MAS and the analogue data were highly significant ($r = .99$, $p < .001$).

An important limitation of the reliability analyses conducted by Durand and Crimmins (1988) is that only correlational procedures were used to calculate inter-rater

reliability. Correlational analyses do not demonstrate that both raters are necessarily in agreement. Significant correlations are possible even if the raters are in complete disagreement, so long as the discordance is uniform. A less restricted reliability procedure is one that measures actual score agreement on an item-by-item basis. For this reason, many replication studies have recommended the use of percentage agreement statistics (Zarcone, Rodgers, Iwata, Rourke, & Dorsey, 1991; Sigafos, Kerr, & Roberts, 1994; Thompson & Emerson, 1995). Percentage agreements are based on the number of agreements expressed as a proportion of the total. They are calculated by dividing the number of agreements by the sum of agreements and disagreements and then multiplying by 100. Two types of percentage agreement statistics can be calculated. The first is based on exact concordance and the other, more lenient measure, counts scores within one point of each other as an agreement. However, the main disadvantage of all percentage agreement statistics is they do not account for agreement expected by chance. Reliability calculated using Cohen's Kappa (κ) coefficient (Cohen, 1960) presents a more conservative option, as it factors for chance agreements. Nevertheless, replication studies have only used percentage agreement statistics and the same correlational procedures used by Durand and Crimmins (1988) to reassess the reliability of the MAS.

Replication studies generally have failed to repeat the favourable results reported by Durand and Crimmins (1988). The one exception has been a study using a South African sample (Akande, 1998), which provided support for the reliability of the MAS. The one psychometric property of the MAS that has been replicated consistently is the internal consistency of the subscales. Newton and Sturmey (1991) and Shogren and Rojahn (2003) reported comparable Cronbach's alpha coefficients for the four subscales, ranging from .77 to .91 and from .80 to .96, respectively. Others have found the internal consistency of the MAS to be satisfactory in spite of more modest alpha values, on average, ranging from .68 to .86 (Bihm, Kienlen, Ness, & Poindexter, 1991; Spreat & Connelly, 1996; Duker & Sigafos, 1998). Aside from the internal consistency, the MAS has been found to be inadequate on various measures of reliability and validity (Zarcone *et al.*, 1991; Newton & Sturmey, 1991; Sigafos *et al.*, 1994; Duker *et al.*, 1998). However replication studies have differed in the extent to which they diverge from the findings of Durand and Crimmins (1988). The reliability data reported by Zarcone and colleagues (1991) were the most convergent. The Pearson correlation coefficients (r) for the item scores, mean scores and ranked category ranged from $-.30$ to $.81$, from $-.80$ to $.99$ and from $-.80$ to 1.0 , respectively. These findings contrast significantly with the coefficient ranges reported in the original reliability analysis (i.e., from $.62$ to $.92$, from $.80$ to $.95$ and from $.66$ to $.81$, respectively). Overall only 15% of

correlational coefficients exceeded the $r = .80$ cut-off and no percentage agreement scores met the 80% standard. Agreement on the primary source of reinforcement for self-injury was reached by only 29% of raters. Reliability analyses across each of the items showed that no specific questions unduly affected agreement between raters. Similarly, Newton and Sturmey (1991) reported a significant correlation ($p < .05$) for only one question and a median inter-rater reliability coefficient of .18. None of the correlations for the mean scores was significant. The failures to replicate the reliability data of Durand and Crimmins (1988) may have been due to the differential characteristics of the raters (Zarcone *et al.*, 1991). The raters recruited by Durand and Crimmins (1988) were distinct because they were highly trained graduates or certified staff with much experience. Another contributory factor may have been the occurrence rate of the target behaviour. The sample considered by Durand and Crimmins (1988) exhibited frequent self-injury that occurred fifteen times an hour on average. Whereas the participants selected by Zarcone and colleagues (1991) displayed low frequency self-injurious behaviours, which ranged from several times an hour to less than once a week. This difference in the frequency of the target behaviour may have accounted for the discrepancy in reliability levels. The raters in the original reliability study presumably would have had more experience of the behaviour and so more opportunities to identify its maintaining contingencies. Indeed the reliability data for moderately frequent behaviours has been found to be modest yet significant ($p < .05$), for all individual and subscale scores (Kearney, 1994).

Other replication studies have focused on whether differences in reliability are associated with the topography of the target behaviour. Sigafos and colleagues (1994) measured reliability of the MAS when used to assess aggressive behaviours. Their findings did not replicate those by Durand and Crimmins (1988) but they were closer than the replication studies mentioned above. Even though the overall Pearson correlation ($r = .034$) across all raters was nonsignificant, significant positive correlations ($p < .05$) were found between 42% of the raters. Agreement on the primary source of reinforcement was recorded by 44% of raters, which is more favourable than the 29% previously reported. Duker and Sigafos (1998) examined the reliability and validity of the MAS for three topographies of aberrant behaviour. The reliability measures in this replication study approximated most closely to those reported by Durand and Crimmins (1988). Target behaviours were assigned to one of three categories of topography, using a categorisation system based on a large scale factor analysis (McGrew, Ittenbach, Bruininks, & Hill, 1991). However the procedure of the classification process or whether any agreement was sought was not stated. Nevertheless, topography was found to have a significant and differential effect on reliability. Inter-rater

reliability was significantly more likely ($p < .05$) with regard to maladaptive and disruptive behaviours as opposed to destructive behaviours. Also the reliability on assessing the primary source of reinforcement was adequate for disruptive behaviour but not for the other two topographies. Overall, significant correlations were reported for item scores (13 items at $p < .001$), mean scores, except for the attention subscale, and for the ranked category scores. Thompson and Emerson (1995) reported unacceptable levels of inter-rater reliability across all topographies of behaviours.

Most replication studies have focused on the reliability of the MAS. Comparatively little research has been conducted into the validity of the instrument. The research carried out has found support for the validity of the MAS, despite its poor reliability. Durand and Crimmins (1988) demonstrated the convergent validity of the MAS by showing increased challenging behaviour during those analogue conditions forecast by the MAS. Other studies have endorsed the predictive validity of the MAS by highlighting the treatment utility of the instrument. Information derived from the MAS has been used as the basis for successful functional communication training and reinforcer selection (Durand *et al.*, 1989; Durand & Carr, 1992; Durand, 1999). Independent authors have evaluated the convergent validity of the MAS with other functional assessment instruments and experimental functional analysis (Paclawskyj, Matson, Rush, Smalls, & Vollmer, 2001; Shogren & Rojahn, 2003). Comparisons between the psychometric properties of the MAS and the Questions About Behavioral Function have differed. Shogren and Rojahn (2003) found significant correlations, at the .001 level (mean $r = .84$), between all the analogous subscales of the MAS and the Questions About Behavioral Function. However, Paclawskyj, Matson and Rush (2001) reported that correlation coefficients between their subscales were lower (mean $r = .67$) and only half were significant ($p < .001$). They also evaluated the convergence between the MAS and experimental functional analysis, using the procedures described by Iwata and colleagues (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982; 1994a). Excluding those cases where the analogue analysis could not establish function, the same primary function was identified by both the MAS and experimental functional analysis only 53.8% of the time. Crawford, Brokel, Schauss and Miltenberger (1992) reported similar findings in their comparison between functional assessment methods. The results of the MAS and the direct observation matched for all four participants but the findings of the experimental functional analysis were ambiguous.

The psychometric data in relation to the construct validity of the MAS have been contradictory. Some authors have endorsed the validity of the MAS subscales (Bihm *et al.*, 1991; Singh *et al.*, 1993) whereas others have rejected a conceptually meaningful four factor

structure (Duker *et al.*, 1998; Kearney, Cook, Chapman, & Bensaheb, 2006). Bihm and colleagues (1991) conducted a principal component factor-analysis with varimax rotation. The eigenvalues for two of the factors were reported to be less than one. Nevertheless the four factors corresponded almost directly to the subscales proposed by Durand and Crimmins (1988). Singh and colleagues (1993) found the factor structure of the MAS was robust only when applied to high-rate challenging behaviour. A four factor solution emerged for the high-rate self-injury sample but only three factors exceeded an eigenvalue of one in the low-rate sample. This inconsistent structure for the low-rate sample emerged even when different methods were used to determine the number of factors. In addition to the occurrence rate, the topography of the behaviour also has been found to affect the construct validity of the MAS. Duker and Sigafoos (1998) conducted a factor analysis of the MAS for three topographies separately. A four factor solution emerged only for destructive behaviour. Five factors with an eigenvalue greater than one were found for maladaptive and disruptive behaviour. The results from the item loadings further indicated a divergence in the factor structure of the MAS according to topography. The authors concluded that the evolved factor structure of the MAS was most meaningful for destructive behaviour and least meaningful for disruptive behaviour.

2.2.2.3.2 Questions About Behavioral Function

Devised by Matson and Vollmer (1995; 2000), the Questions About Behavioral Function (QABF) is a questionnaire designed to identify causal and maintaining variables of maladaptive behaviours. The QABF is a 25-item structured questionnaire comprising five subscales. Each subscale represents a different form of stimulus condition. Similar to the MAS, the QABF subscales include three environmental contingencies that maintain challenging behaviours (attention, tangibles and escape) and a non-social contingency of automatic / self-stimulatory reinforcement. The fifth subscale is a defining feature of the QABF that makes it more comprehensive. This fifth factor relates to the physiological state of the client, as a potential stimulus condition for challenging behaviour. Physical subscale items about pain or discomfort are especially pertinent for the brain injury population. The questionnaire is administered to a third party who is well acquainted with the client. Respondents offer their informed opinion concerning the circumstances surrounding the client's challenging behaviours. Responses are recorded using a 4-point Likert scale, ranging from 'never' to 'often', with an additional endorsement of 'does not apply'. Two summary scores can be calculated for each subscale. The endorsement score represents the number of items with a score above one and the severity score is the total (or mean) score of the

endorsements. The QABF output is an item endorsement and severity score for each of the five subscales.

Unlike the MAS, the QABF scale does not evidence poor reliability. The developers of the QABF have found it to be a reliable instrument that is stable over time (Paclawskyj, Matson, Rush, Smalls & Vollmer, 2000). On an individual item basis, inter-rater and test-retest reliabilities were consistently high across three measures of reliability, Spearman's rank-order correlations (ρ), percentage agreement and Cohen's Kappa (κ). In most cases these values exceeded the minimum standards of acceptability. In terms of the total and subscale scores, Pearson product-moment coefficients (r) were high and significant ($p < .001$) for both inter-rater and test-retest reliabilities, with coefficients ranging from .79 to .99 and from .80 to .99, respectively. The internal reliability of the instrument was also substantial. The Cronbach's alpha values for individual subscales ranged from .90 to .93 and the alpha coefficient was .60 for the QABF as a whole. A limitation of the psychometric data provided by Paclawskyj and colleagues (2000) concerns the small sample size used. Test-retest reliability was calculated using only 34 participants and the inter-rater portion of the study included (inexplicably) a further 23 participants. Nevertheless, their findings still were congruent with those of other replication studies. Although generally the reliability data reported in the replication studies were less impressive than those stated by the QABF developers. Shogren and Rojahn (2003) found the inter-rater and test-retest reliability coefficients ranged from .46 to .60 and from .62 to .93, respectively. Using interpretative guidelines, the inter-rater reliability for the QABF subscales was described as fair to good and the test-retest reliability as good to excellent. Regarding the internal consistency of the QABF, the physical subscale yielded a Cronbach's alpha value of only .24 while the alpha coefficients ranged from .82 to .88 for the other four subscales. The findings of Shogren and Rojahn (2003) were similar in many respects to those in the replication study conducted by Nicholson, Konstantinidi and Furniss (2006). An important difference between them was that the later study reported robust internal consistency for all subscales, including the physical subscale, with alpha coefficients ranging from .79 to .92. Another difference is that Nicholson and colleagues (2006) reported greater variability in their measures of inter-rater reliability, which they describe as modest.

Psychometric data in relation to the five QABF subscales have shown that the functions are statistically meaningful and relevant in applied settings. The heterogeneity of the QABF scales was confirmed by factor analysis (Paclawskyj, Matson, Rush, Smalls, & Vollmer, 2000). An exploratory factor-analysis with varimax rotation yielded five factors that accounted for 76.1% of the variance shared by the test items. These five factors corresponded

to the proposed subscales of the QABF. These findings replicated almost exactly those reported originally by Matson and colleagues (1996; cited in Paclawskyj *et al.*, 2000). They conducted the same factor analysis and also discovered a corresponding five-factor solution that accounted for 74.5% of the total variance. The factor analysis conducted by Nicholson, Konstantinidi and Furniss (2006) further supported these findings. In their study, again, five factors emerged that matched to the five subscales of the QABF and accounted for 73% of the variance in item scores. However their analyses introduced the possibility of an additional sixth factor, relating to a single item about the repetitive nature of the behaviour. An adopted version of the QABF has been developed for use with individuals suffering with psychiatric illness (Singh *et al.*, 2006). The psychometric data for the revised scale closely corresponded to those originally reported for the QABF. The psychometric properties of the QABF also were established when administering the instrument to a paediatric sample (Freeman, Walker, & Kaufman, 2007).

The validity of the QABF proclaimed by the developers has been supported by various studies. The procedure of validity studies has been either to examine the treatment effects of the QABF or to compare the instrument to an experimental functional analysis technique. Matson, Bamburg, Cherry and Paclawskyj (1999) endorsed the predictive validity of the QABF in their demonstration of treatment utility. They examined three topographies of challenging behaviour and measured changes in their occurrence following a six month treatment period. The treatment plan for the experimental group was based on functional assessment information derived from the QABF. Intervention for the control group was not based on any functional assessment and instead followed a standard protocol, consisting of interrupting, blocking and redirecting. Both groups demonstrated a reduction in challenging behaviour following their respective treatment period. However, the gains of the experimental group were about three times greater than those of the control group, across all three topographies. Separate one-way analysis of covariance revealed significant treatment effects for the self-injury group [$F(2, 57) = 18.32, p < .001$], the aggression group [$F(2, 57) = 59.87, p < .001$] and for the stereotypies group [$F(2, 57) = 78.45, p < .001$]. The robust findings of this validity study were not without limitations. First, it was concluded that behavioural treatments tailored to the function of the challenging behaviour were more effective than non-specific interventions. However no elaboration on the type of intervention programs actually used for the experimental group was provided. Also it was proposed that the QABF could identify correctly behavioural function and so improve treatment success. However, all the study participants exhibited only one form of challenging behaviour. Had the QABF been used to assess the function of multiple topographies then its predictive validity may have

differed. Indeed to date there have been no demonstrations on the psychometric properties of the QABF when used for multiple behaviours. Paclawskyj, Matson and Rush (2001) evaluated the convergent validity of the QABF with experimental functional analysis, as per the procedures described by Iwata and colleagues (1982; 1994a). All participants were included in the analogue analyses but function was not established in 23% of cases. Undifferentiated results have been a common limitation of analogue analyses (Martin, Gaffan, & Williams, 1999). Excluding these undifferentiated cases, the same primary function was identified by both the QABF and experimental functional analysis 69.2% of the time. Hall (2005) reported a greater agreement rate of 75% and found support for the validity of the QABF.

On the whole research has suggested that the QABF is a psychometrically robust instrument with sound reliability and validity. The application and utility of the QABF for functional assessment has been expansive. The QABF has been invaluable for conducting large group studies because of its brief and easy administration. The interview and scoring process took between 20 and 30 minutes only (Matson *et al.*, 1999a; Paclawskyj *et al.*, 2000). Applegate, Matson and Cherry (1999) used the QABF to conduct a large scale examination of behavioural function across five different topographies. The QABF identified a primary function for every person in the sample ($n = 417$). Separate one-way ANOVA's for each subscale revealed a significant difference ($p < .001$) between functions for all five behaviour topographies. Matson and colleagues (1999a) found that the QABF identified function for 84% of participants ($n = 398$) who exhibited one form of challenging behaviour. However, the success rate for establishing function varied according to the topography of the behaviour. The QABF successfully identified function for 83% of the self-injury group, 74% of the aggression and 93% of the stereotypy group. The QABF has been used to assess less typical topographies such as various feeding problems (Matson *et al.*, 2005) and handmouthing (Swender, Matson, Mayville, Gonzalez, & McDowell, 2006). It has been applied to various population groups including those with autism, non-specified developmental disorders (Dawson, Matson, & Cherry, 1998), and intellectual disabilities, both with and without psychiatric disturbance (Matson & Mayville, 2001). The QABF has been used to classify function to facilitate supplementary research into social functioning (Matson, Mayville, & Lott, 2002) and seizure disorders (Matson, Bamburg, Mayville, & Khan, 1999).

Many different procedures have been used to determine behavioural function using the QABF. The interpretation of the QABF output has varied according to the author and the study. Some authors have failed to state the technique used to ascribe function (Dawson *et al.*, 1998; Paclawskyj *et al.*, 2000; Matson *et al.*, 2005). Others have identified behavioural

function according to item endorsement. Matson and colleagues (1999a) ascribed function where a subscale had at least four (out of a possible five) item endorsements and no other subscale had more than two endorsements. The existence of multiple maintaining variables was not possible using this procedure. Instead elevated endorsements were translated as an undifferentiated finding. Some authors have identified behavioural function in terms of severity score. Using the methodology described in Matson and Vollmer (1995), Paclawskyj and colleagues (2001) and Matson and Mayville (2001) determined function where a subscale received a greater total score than the others. The concept of a behaviour serving multiple functions was allowed for using this procedure. Subscales with equal severity scores all would have been labelled the primary function of the behaviour. The procedure used by some authors was based on a combination of the severity and endorsement techniques. Matson and colleagues (2002) assigned function where the score of a subscale exceeded three and no other subscale had any item endorsements. Some authors have examined the overall profiles of participants and presented summary statistics for all the prominent antecedents, without determining the primary function (Matson *et al.*, 1999b). Other studies have examined all subscale scores closer and conducted an analysis of variance to test for significant differences between behavioural function (Applegate, Matson, & Cherry, 1999; Swender *et al.*, 2006). Any factor that significantly differed from the others was taken to be the function of the behaviour. However, regardless of a significant effect similar mean scores were possible still with this procedure. Applegate, Matson and Cherry (1999) reported that non-social factors maintained self-injury despite little variability between the other factors. A significant difference existed between the functions for self-injury [$F(4,488) = 9.53, p < .001$] and the non-social subscale received the highest score ($M = 5.47$). Nevertheless there was a grouping of scores on the remaining subscales (escape, $M = 3.54$; attention, $M = 2.89$; tangible, $M = 2.37$; physical, $M = 1.97$). Another difficulty in interpretation arose with regard to aggression. The authors found that aggression was most sensitive to environmental factors. Despite the escape variable ($M = 6.02$) being significantly different, there was again clumping between the other environmental factors (attention, $M = 4.79$; tangibles, $M = 5.63$). So while the reasons for aggression were clearly environmental it was difficult to establish which specific social factors were relevant.

2.2.3 *Descriptive Analysis*

A descriptive analysis is a functional assessment methodology that involves the direct observation of challenging behaviours within their natural context. Descriptive analyses assess naturally occurring interactions between challenging behaviours and social stimuli. The

naturalistic observations of a descriptive analysis negate any artificial manipulation of environmental conditions, which are suspected to be influential (Mace & Lalli, 1991). The data output of descriptive analyses is correlational and suggestive of functional relationships operating in the actual environment. Inferences about the maintaining variables of the challenging behaviour are made when a high or significant correlation exists between the target behaviour and environmental events. Descriptive data are used to form hypotheses about behavioural function.

Descriptive analysis methods are hierarchically ordered according to the level of detail they provide. Each method offers a different standard of information. The more advanced data collection methods have the associated costs of increased time and resources. The most basic form of a descriptive analysis merely provides a temporal distribution of the target behaviour. For instance, the scatter plot method (Touchette, Macdonald, & Langer, 1985) collects data only on the timing of challenging behaviour occurrences. Details about the specific environmental antecedents and consequences are not coded. Instead general information such as location, type of activity, persons present and other circumstances are identified (Luiselli, 1991). A more rigorous form of descriptive analysis offers a descriptive narrative of the target behaviour in its natural context. Event recording techniques, such as narrative accounts (Carr *et al.*, 1994) or A-B-C charts (Pyles & Bailey, 1990), provide general information about the events that precede and follow the target behaviour in a given situation. Observational sequential analysis methods are the most progressive kind of descriptive analysis. They depict how well past events predict future ones based upon an analysis of probability. Sequential relationships between variables are identified through calculations based on either events (Mace, Lalli, & Pinter-Lalli, 1991) or time (Emerson, Thompson, Reeves, Henderson, & Robertson, 1995).

The observational methodology of descriptive analyses provides a more objective functional assessment than informant-based assessments. However, the validity of all direct measurements may be compromised by the subjective inferences of the observer. Various observer effects can undermine a descriptive analysis, such as selective attention, partial encoding and misinterpretations of events (Robson, 1993). Such observation biases can be minimised with clearly defined operational definitions. Nevertheless, the external validity of a descriptive analysis would still be threatened if the range of conditions observed were not comprehensive (Sasso *et al.*, 1992). Also caregivers may purposefully manipulate the environment to avoid the occurrence of challenging behaviours. As such, only a constrained set of functions would emerge from a descriptive study that is confined to a restricted array of observational conditions (Day, Horner, & O'Neill, 1994). Descriptive analyses have the

advantage of being easy to administer. Comparatively little time is required to collect, analyse and interpret the data, which makes descriptive assessments effective in clinical settings. Although its efficiency is questionable if the challenging behaviour is infrequent or maintained on an intermittent reinforcing schedule. The data output of all descriptive analysis methodologies is correlational. The technology can only offer suggestions of functional relationships since it does not directly assess cause. This means that descriptive assessments lack the precision and rigour of experimental functional analysis methods. However, they do provide a clinically relevant and efficient way of formulating hypotheses, which can then be tested more empirically by experimental analysis.

2.2.3.1 *Scatter Plot*

Touchette, MacDonald and Langer (1985) established a way to identify temporal patterns in behavioural responding. The procedure involved recording changes in the rate of challenging behaviour within each day and across multiple days. These recordings were made on a specific grid called a scatter plot. A scatter plot analysis is based on the premise that challenging behaviours do not occur at a steady rate. It is supposed that bursts of behaviour are interspersed with periods of non-responding. The presence or absence of the target behaviour in relation to the time of day is recorded on the scatter plot. The day is segmented into units of time on the vertical axis of the scatter plot. The unit time can be varied so that each vertical segment may represent either a full, half or quarter hour interval. The occurrence rate of the target behaviour is charted according to a predetermined partial-interval category system. For instance, Touchette and colleagues (1985) represented a high-rate, low-rate and zero-rate behaviour with a filled-in, outlined and empty cell, respectively. The authors recommended no more than three categories to ease meaningful interpretation. Data collected on consecutive days are recorded on the successive columns along the horizontal of the scatter plot.

The scatter plot is an efficient tool that is used often in clinical settings (Ellingson, Miltenberger, & Long, 1999). Little training and time is required to administer a scatter plot analysis. Data can be recorded by staff members alongside their clinical duties. Interim results may emerge as the data are input progressively directly on the grid. The scatter plot chart is interpreted visually and requires no calculations. The rate of responding in relation to time is revealed in the output. A change in the pattern of responding is signified to be a shift in the environment setting. Clinical records are examined to determine which environmental settings actually occurred at that time. Such influential setting events could be a therapeutic activity, scheduled event, meal time, physical environment or the presence of a staff member. Broad

aspects of contextual control can be identified with a scatter plot. In order to determine the precise maintaining variables further investigation would be required. However, such detailed follow-up analyses may not always be necessary. Touchette and colleagues (1985) claimed that stimulus control was established when changes in behavioural rate corresponded to changes in setting. They demonstrated that problem behaviours could be reduced successfully without identifying the exact controlling stimuli. The schedules of three clients were altered on the basis of scatter plot information only. Either stimuli that controlled high rate challenging behaviours were removed (a therapeutic class / a member of staff) or stimuli that controlled low rate challenging behaviours were introduced (a morning activity schedule for the evening time).

The reliability and validity of the scatter plot have not been demonstrated comprehensively. Touchette and colleagues (1985) presented three case studies above as validity data for the scatter plot. However the generality of their findings was restricted because of their small sample. The authors also reported perfect interobserver agreement throughout these studies. Their reliability analyses were limited due to a number of issues. The percentage agreement statistic used did not account for agreement expected by chance, the proportion of the total time conducted by the second observer was not stipulated and the unit of analysis used for the agreement calculation was different to the time interval used originally in the scatter plot. Only one replication study has been conducted to date. Kahng and colleagues (1998) used both visual inspection and statistical analyses to interpret scatter plot data of 20 clients with severe mental retardation. A mean agreement score of 80.6% was reported (range from 29.6% to 97.1%), using the same interobserver calculations as the original study. A group of eight evaluators failed to see any clear behavioural patterns in any of the included data set. However, in 80% of these cases a temporal pattern of responding did emerge when a statistical analysis was used. The validity of the scatter plot is undermined by this possibility that its data array output can escape visual detection.

The scatter plot is used often in clinical practice despite the fact that its reliability and validity has not been demonstrated. Desrochers, Hile and Williams-Moseley (1997) conducted a survey of functional assessment procedures used by members of the Psychology Division of the American Association of Mental Retardation. About two-thirds of the sample ($n = 120$) had used the scatter plot to assess self-injurious behaviour. Of these around a third (32.5%; $n = 120$) had used it for at least 10% of all their cases. In a similar study, Ellingson and colleagues (1999) reported that just under a third of practitioners had used the scatter plot for at least 20% of their clients. In the literature, many studies have used scatter plot

technology but none have reported the actual scatter plot data (e.g., Lennox & Miltenberger, 1989; Lalli, Browder, Mace, & Brown, 1993; Kennedy & Itkonen, 1993; Persel *et al.*, 1997).

In summary, general information about the temporal distribution of a challenging behaviour is provided by a scatter plot. Behavioural occurrences are categorised in each predetermined unit of time. Specific incidents are not all documented or counted. The scatter plot is administered easily and is used widely in clinical settings. The influences of scheduled activities and events on behaviour are highlighted. This information can be utilised to modify relevant elements of a client's clinical schedule. Otherwise information on broad aspects of stimulus control is limited in value. No detailed information about the maintaining contingencies of challenging behaviour is provided. Also the behavioural context, antecedents and consequences of the challenging behaviour are not identified. However, the output of the scatter plot can be used as the basis for further, more in-depth investigation into the specific stimulus control. A scatter plot assessment is limited to a single challenging behaviour at any time. Multiple challenging behaviours or different topographies of target behaviour cannot be measured. Also sequences of behaviours or behaviours serving multiple functions can never be identified using the technology. Although the scatter plot can be applied to an infrequently occurring behaviour its behavioural distributions may be indistinguishable. The scatter plot is interpreted visually but behavioural patterns may not always be transparent. Support for the reliability of the scatter plot has been documented only in a very small number of studies. Many studies have made reference to the treatment utility of the scatter plot without making the output data or its validity explicit.

2.2.3.2 *A-B-C Event Recording Techniques*

A descriptive assessment type that presents the context of challenging behaviours is exemplified by a narrative account. A narrative account is an observational method in which the circumstances surrounding the target behaviours are described. A written document of the environmental events that immediately precede and follow each occurrence of the challenging behaviour is provided. First the data are recorded in shorthand, dictated on an audiotape or recorded on film. Then they are transcribed into the form of a narrative account, which offers a descriptive account of environmental events in the order they occurred. The clinical value of this technique is limited due to the inordinate amount of time needed to decode the data. Consequently narrative accounts are often only used in the preliminary stages of a study (Murphy, 1987). Still, narrative recordings provide useful introductory information on the general antecedent conditions and consequent events of the challenging behaviours. They also offer additional contextual information, such as time, setting and people present. Narrative

recordings are a form of an A-B-C event recording technique, which depicts the antecedent events (A), the behavioural response (B) and the consequent event (C). One example is the use of record cards proposed by Carr and colleagues (1994) to describe the ‘interpersonal context’ of a challenging behaviour and the ‘social reaction’ to it.

Various authors have formalised more practical procedures for conducting event based A-B-C assessments. Rather than a narrative recording method, checklists have been proposed as more suitable means of data collection. These A-B-C charts comprise an inventory of challenging behaviours, antecedent conditions and consequent events. Caregivers simply record the incident of the challenging behaviour and the events that occurred before and after its occurrence by ticking the appropriate box from the list. Pyles and Bailey (1990) developed the ‘Inappropriate Behavior Record’ as a descriptive assessment tool for treatment selection. In addition to listing the most common antecedent and consequent events, the chart included an all-encompassing option check box for ‘other’ events. The recording of multiple events and conditions was possible with the chart. Data were collected over a long period of time (6 weeks) and were analysed using a graph to tally the most frequently occurring environmental events. Separate graphs were composed for each behavioural. The ‘Functional Analysis Observation Form’ (O’Neill *et al.*, 1997) amalgamates scatter plot technology with an A-B-C analysis.

Approaches that use A-B-C charts have a number of limitations associated with them. The checklists are designed to be used by caregivers alongside their normal duties. Practical work demands may mean that not all incidents are actually recorded. Moreover, there is the possibility that not all events will be accurately observed. Especially true for antecedent conditions, retrospective recall will lead to an inaccurate recording. Also, on the checklist, the ‘other’ option encompasses all events that do not fall within the predefined categories. This requires the caregiver to specify the nature of the environmental event observed. These descriptions may be distorted by subjective interpretations, inferences of intention or biased reporting due to pre-existing beliefs. Furthermore, there are limitations concerning the analysis of the data. There are no objective criteria to assess the prominence of one environmental event over another. The relative impact of environmental stimuli is considered only in terms of frequency. There is no objective measure to assess the extent of their influence on the target behaviour. It is not possible to calculate the conditional probability of a challenging behaviour occurring given an antecedent event or to assess the likelihood of a social event following the target behaviour. Without the facility to conduct an analysis of probabilities, an A-B-C event based recording technique can only generate limited information regarding sequences of stimuli and responses.

Despite its weaknesses, A-B-C analyses have been used extensively in applied settings. Ellingson and colleagues (1999) reported that A-B-C assessments were the most commonly used form of descriptive analysis in clinical settings. The A-B-C assessment has been manipulated in order for the descriptive analysis to focus specifically on the behaviour (Taylor & Romanczyk, 1994), the antecedent (Tustin, Bond, & Forsaith, 1997) or the consequence (Thompson & Iwata, 2001).

2.2.3.3 *Sequential Analysis*

Sequential analysis is a method for describing how well past events predict future ones. It is a non-parametric statistical technique that is concerned with repetitions in the temporal connections within and between events (Sackett, 1987). All sequential analysis models adopt the transitional approach, which involves determining the conditional probability of the target variable occurring given the occurrence of another variable. This conditional probability can then be compared to the (unconditional) probability of the target variable occurring under all conditions (Vollmer *et al.*, 2001). A significant difference between the probabilities would indicate a relationship between the stimuli. So the sequential relationship between a pair of variables is determined by examining the likelihood of their occurrence in relation to each other. The identification of such sequences can be based upon either time or events (Repp, Felce, & Karsh, 1991). Both event-based and time-based sequential analyses have been established in observational research as valid sources of detailed information with which to make sound statistically based clinical decisions (Sackett, 1987; Moran, Dumas, & Symons, 1992; Bakeman & Gottman, 1997).

2.2.3.3.1 Event-based Sequential Analysis

A seminal paper by Bijou, Peterson and Ault (1968) formed the guiding principles for examining sequential relationships between challenging behaviours and environmental events. Its theoretical and procedural rationale has continued to influence descriptive analysis methodology. The authors adopted a more structured approach to A-B-C analysis using a time-sampling recording procedure. Each column of the proposed data record sheet represented a consecutive time interval. A marked column symbolised occurrence during that predetermined unit of time. Each row of the data record sheet corresponded to a particular social stimulus class. So each row related to the challenging behaviour, antecedent events or subsequent events. There were multiple categories within each of these three stimulus classes that allowed for the recording of several events simultaneously. A predetermined system of symbols was used to represent social stimuli. This enabled clear and efficient recording. The

extent to which the stimuli were recorded as global or refined events was prescribed within this recording system.

This formative observation method allowed a more rigorous analysis of environmental events in relation to challenging behaviours. The target behaviour can be summarized in terms of frequency, rate and average duration. The extent to which environmental events are related to the target behaviour can be quantified using a conditional probability analysis. The conditional probability is expressed as the likelihood of a challenging behaviour occurring given the occurrence of a preceding event. In this way, the potency of each antecedent event to evoke the challenging behaviour can be measured. Events that are likely to be followed by the challenging behaviour are considered to act as their discriminative stimulus or establishing operation. Similarly, conditional probability calculations can be applied for the consequent events. The likelihood of an event occurring given the occurrence of the challenging behaviour can be calculated. In this way, the strength of the relationship between the target behaviour and its subsequent event can be measured. Then the extent of the variable schedule of reinforcement would be indicated. Hypotheses about controlling variables can be determined from consistent correlational relationships.

Mace, Lalli and Pinter-Lalli (1991) formalised a revised form of a sequential analysis based on the original work of Bijou and colleagues (1968). Their data sheet comprised three separate grids split into 10-second time intervals. All events are recorded continuously in the first grid due to the fact that any event can potentially be a discriminative stimulus or establishing operation. The second grid is used to record occurrences of multiple challenging behaviours. Then subsequent events occurring within two intervals after the target behaviour are recorded in the third grid. Other authors have adopted similar procedures for identifying behavioural contingencies of various problem behaviours. Event-based sequential analyses have been applied to stereotypy (Mace & Belfiore, 1990; Tang, Kennedy, Koppekin, & Caruso, 2002), bizarre speech (Mace & Lalli, 1991), self-injurious behaviour (Lerman & Iwata, 1993) and general aberrant behaviour (Sasso *et al.*, 1992; Lalli *et al.*, 1993).

Event-based sequential analysis using time-sampling recording methods are constrained by various theoretical and practical limitations. Some of its disadvantages are inherent to all paper-and-pen observational methods. The assessment is restricted to one target behaviour at a time and so multiple topographies cannot be measured simultaneously. Also infrequently occurring behaviours can be evaluated but a lengthy assessment period would be needed. So an extensive amount of data would be required for a consistent temporal pattern to emerge. In addition, the focus of the assessment is based on occurrences of challenging behaviours. Environmental events are recorded only in relation to the presence of the target

behaviour. During periods when the target behaviour is absent environmental events are not accounted for. However, it is highly possible that environmental events may be correlated with the nonoccurrence of challenging behaviour (Lerman *et al.*, 1993). As such, all possible behavioural contingencies cannot be revealed by the methodology. For instance, the assessment would not highlight instances of a target behaviour occasioned by the absence of an environment event. The accuracy of such assessments can be further compromised by practical recording issues like the coding of events with a duration greater than the time interval or coding events that occur simultaneously.

Some of the disadvantages are due to the time-sampling procedures adopted. The output quality of a time-sampling technique is restricted by a number of factors. Partial-interval recording means that multiple occurrences of an event within a particular time interval are recorded as a single incident. So the actual frequency count of the event would be flawed. Consequently the maximum overall frequency rate is determined by the length of the time interval. The length of the time interval has to be determined beforehand and should reflect the (expected) rate of the target behaviour. A short time interval should be used for high frequency behaviours and vice versa. However, there is no standard instruction on how to relate these variables in order for the time interval to be determined. The importance of an appropriate time interval length cannot be overestimated. The richness of the data yielded is influenced by the size of the time interval. For instance, suppose the output showed that event A took place during the first 15 second interval and then in the next interval events B and C occurred. The exact sequence during the second interval cannot be deciphered. Event B may have preceded event C or the other way round. Also, without exact timings, the gap between events cannot be known. The output showed that event A was followed by event B but the time difference between both events is unknown. The events could have occurred at the beginning or end of their time interval. So the delay between events A and B could have ranged anywhere between one and 29 seconds. These two limitations on the quality of the results become more pronounced as the size of the interval increases. Finally, the question of what constitutes a contiguous environmental event has to be settled. Temporal parameters are needed so that only events within a specified number of time intervals either side of the target behaviour are recorded.

The prevalent use of A-B-C assessments in clinical settings has occurred despite any formal appraisal of reliability or validity. No investigation has been conducted into the psychometric properties of A-B-C assessments. However, incidental measures of reliability and validity have been reported in studies that have administered the technique. The mean average interobserver agreement across the aforementioned studies (Mace & Belfiore, 1990;

Mace & Lalli, 1991; Sasso *et al.*, 1992; Lalli *et al.*, 1993; Lerman & Iwata, 1993; Tang *et al.*, 2002) was 89%. The convergent validity of A-B-C assessments was assessed in some of the studies. The findings of the A-B-C assessments were compared with those derived from experimental functional analysis. In two single case studies the naturalistic and analogue analyses were found to be concordant (Mace & Belfiore, 1990; Tang *et al.*, 2002). Other studies have measured the treatment validity of A-B-C assessments, in addition to its convergent validity. The clinical utility of A-B-C assessments was gauged by examining the effectiveness of intervention programmes based upon emergent hypotheses. In seven cases both functional assessment methods produced identical hypotheses which then were used to drive successful interventions programmes (Sasso *et al.*, 1992; Lalli *et al.*, 1993). Other studies have reported some discrepancy between the functional assessment methods. Mace and Lalli (1991) discovered that, in a single case study, two hypotheses emerged from the descriptive analysis but only one was supported by the experimental functional analysis. The intervention plan based on both hypotheses was effective. Lerman and colleagues (1993) reported that the findings of the descriptive analysis failed to correspond with those of the experimental functional analysis in five out of six cases.

2.2.3.3.2 Time-based Sequential Analysis

Computer-assisted technology has transformed the recording of direct observational data. Initially computers were used to facilitate time-sampling and interval-recording procedures (Pageot, Kvale, Mace, & Sharkey, 1988). Early electronic data collection techniques provided an advanced level of analysis compared to traditional paper-and-pen methods (Baumeister, MacLean, Kelly, & Kasari, 1980). However, the true technological benefit was the real-time capabilities of computers, which provided the capability to analyse sequences of behaviours (Repp, Karsh, Felce, & Ludwig, 1989). This meant that observational data could be collected by recording multiple behaviours simultaneously in real time (Robson, 1993). Bespoke computer programmes were written that enabled continuous observational recordings and offered outputs in terms of basic behavioural sequences (Repp, Harman, Felce, Vanacker, & Karsh, 1989; Repp, Karsh, Van Acker, Felce, & Harman, 1989; Repp & Felce, 1990). Today many advanced real-time observational software systems have been developed and are commercially available. Some integrated software packages for the collection and analysis of observational data include ObsWin (Martin, Oliver, & Hall, 2001), SDIS / GSEQ (Bakeman & Quera, 1995), the Observer (Noldus, 1991) and CTS (McGill, Hewson, & Emerson, 1994). The use of computers to collect and analyse data has now become increasingly important in both applied and research settings (Kahng & Iwata, 2000).

The use of handheld computers for data collection has associated costs. Resources are required for training and time is needed to collect and analyse data. As such, the cost-benefit balance may make the method inappropriate for low-frequency behaviours. On the whole, however, any such disadvantages are outweighed by its many benefits. The use of computer assisted technology to collect observational data has allowed sophisticated observational techniques and analyses possible (Hall & Oliver, 2000). It provides a rich data record. Behaviours can be characterised along multiple dimensions, such as form, frequency, rate, duration, latency, intensity and sequence (Symons & MacLean, 2000). Data analysis can be conducted in terms of these dimensions and all variable codes can be transformed further with Boolean operations. The behaviours may be recorded as discrete categorical variables or continuous durational variables (Sackett, 1987; Repp *et al.*, 1991). The following standard computations can be made with computerised data collection systems: central tendencies, variability, interobserver agreement and sequential analysis. The unique strength of time-based sequential analysis is its ability to measure the conditional probability of challenging behaviour occurring given the presence of an environment variable. This dependent probability can be compared to the (unconditional) probability of that environmental event occurring anyway (Vollmer *et al.*, 2001). In this way significant relationships between challenging behaviours and stimuli can be determined.

Time-based lag sequential analysis has been used by various authors. Its application in the functional assessment of those with severe learning disabilities has been illustrated (Emerson *et al.*, 1996). The utility of the method was shown in its identification of behavioural processes and response classes. It has been conducted on multiple topographies and settings (Emerson *et al.*, 1995). The behavioural functions derived from these results were validated with brief experimental analysis, as described in section 2.2.4. The tools of sequential analysis have been used to examine the effects of staff support on engagement, and hence their associations with challenging associations (Emerson, Hatton, Robertson, Henderson, & Cooper, 1999). The methodology has also been applied to show support for the functional nature of behavioural excesses shown by adults with dementia and Down syndrome (Millichap *et al.*, 2003).

Some have adopted an alternative approach to time-based lag sequential analysis to examine social interactions (Hall & Oliver, 1997; Hall *et al.*, 2000). The normalise-and-pool variant provides an account of the distributive trends between social stimuli. The conditional probabilities of an environment event occurring at each percentile interval before, during and after the occurrence of another stimulus are determined. This calculation at all the percentile intervals requires the standardisation of periods of time. The graphical output presents the

patterns of social interactions. This summary can be visually inspected to determine whether the resultant profile of responding corresponds to a process of mutual reinforcement (Oliver, Hall, & Murphy, 2005). The method offers an alternative way of detecting temporal associations between a pair of events that is intuitive and more relevant in applied settings (Hall *et al.*, 1997). The normalise-and-pool method to sequential analysis can offer detailed information. Hall and Oliver (1992) presented a single case study to examine the reciprocal nature of self-injurious behaviour and social contact. The investigation concerned the differing effects of varying durations of two forms of self-injury. Evidence suggested that short burst of SIB became less aversive to staff, due to desensitisation, and that longer bursts were more likely to evoke social contact.

2.2.4 Experimental Functional Analysis

The findings derived from descriptive analyses are correlational. Such inferences can only be tested empirically using methods of experimental functional analysis. Experimental functional analysis involves the systematic manipulation of variables to identify those that control and maintain the target behaviour. This requires contrasting an experimental condition that incorporates the variable of interest with a control condition, in which the variable is absent. These conditions are alternated methodically. Experimental control is demonstrated when a change in conditions brings an associated change in behaviour. Behaviour change is observed by measuring the rate, duration or intensity of the target behaviour. All manipulations of these environmental conditions are conducted within an artificial setting. Both the physical setting and the presentation of variables are designed to reflect those occurring in the natural setting. All methods of experimental analysis take the form of a single case experimental design. There are two broad methods of experimental analyses. The first main approach involves the presenting and withdrawing of various antecedent stimuli (Carr & Durand, 1985). The second approach is one in which consequences, contingent on the target behaviour, are changed in an alternating treatment design (Iwata *et al.*, 1982; 1994a).

The first method of experimental functional analysis evolved from a series of investigations that sought to isolate the antecedent variables controlling challenging behaviour (Carr, Newsom, & Binkoff, 1976; 1980). Carr and Durand (1985) formalised this assessment procedure by examining the influence of attention- and escape-maintained social reinforcement processes. The procedure involved three conditions that differed from each other only in terms of attention or task difficulty. The baseline condition, which involved high attention and an easy task, was presupposed to result in a low occurrence of challenging behaviour. This control condition was compared against the two other experimental

conditions, which were alternated in a reversal design. The two experimental conditions involved either low attention and an easy task or high attention and a difficult task. The comparison between the baseline condition and the first condition (i.e. high attention / easy task vs. low attention / easy task) enabled the effects of attention to be examined, given the constant task difficulty. Attention-maintained behaviours were expected to occur at a higher rate during this condition. The comparison involving the second condition (i.e. high attention / easy task vs. high attention / difficult task) pertained to the effects of task difficulty, as attention was held constant throughout. Behaviours maintained by demand escape were expected to occur at a higher rate during this condition. Using the rationale originally proposed by the authors (Durand & Carr, 1991; 1992), the number of experimental conditions has also been increased to incorporate additional behavioural contingencies. Two further analogue settings have been introduced (Durand & Crimmins, 1988; Durand, 1999). The baseline condition was amended slightly to include frequent access to tangibles. Then a new setting was constructed that involved rewarding every ninth correct answer with a favourite item. Social attention remained constant throughout and the only change was the decrease in access to preferred items. Behaviours maintained by tangible consequences were expected to increase during this condition. The other new experimental condition was unstructured and provided free access to tangibles, attention and task materials, which were all under the volition of the participant. Behaviours maintained by internal, non-social factors would be expected to increase during this condition.

The model of experimental functional analysis generally adopted by applied behaviour analysts was pioneered by Iwata and colleagues (1982; 1994a). The methodology involves exposing participants to a series of randomly presented conditions, to assess the sensitivity of the target behaviour to operant processes. The multielement design includes three experimental conditions, pertinent to either a positive, negative and automatic reinforcement process. The first experimental condition involves the presentation of attention contingent on the target behaviour. All other responses are ignored. Challenging behaviours maintained by positive reinforcement by attention are more likely to occur under this social disapproval condition. The next condition approximated to a social context in which behaviours maintained by escaping demands would increase. This academic demand condition involves the presentation of difficult education activities using a learning trial. Praise is delivered for task completion but the task was withdrawn following each occurrence of the target behaviour. Challenging behaviours maintained through a process of negative reinforcement would proliferate during this condition. The last experimental condition, which consists of an impoverished environment with no access to external sources of stimulation,

seeks to elicit challenging behaviours reinforced by intrinsic, perceptual consequences. The control condition presents an enriched environment in which unstructured play occurs. It is characterised by attention for appropriate behaviour, an absence of demands and access to stimulating materials.

Experimental functional analysis has been applied to various populations to examine an array of issues. The methodology proposed by Iwata and colleagues (1982; 1994a) has proved to be a significant advancement in the field of applied behaviour analysis (Neef, 1994). This functional analysis method has been used in the assessment and treatment of self-injurious behaviour (Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994), destructive behaviours (Bowman, Fisher, Thompson, & Piazza, 1997), inappropriate sexual behaviour (Fyffe *et al.*, 2004), eye poking (Kennedy & Souza, 1995), repetitive physical behaviours (Wales, Charman, & Mount, 2004), vocal stereotypy (Ahearn, Clark, MacDonald, & Chung, 2007), pica (Piazza, Hanley, & Fisher, 1996), feeding problems (Munk & Repp, 1994) and multiply controlled challenging behaviours (Smith, Iwata, Vollmer, & Zarcone, 1993). Its application has extended to multiple groups, including dementia patients (Baker, Hanley, & Mathews, 2006), autistic children (Tang *et al.*, 2002), ADHD sufferers (Dicesare, McAdam, Toner, & Varrell, 2005) and brain-injured adults (Pace, Ivancic, & Jefferson, 1994). The methodology has been used to examine the effects of various pharmacological interventions as establishing operations, such as methylphenidate (i.e. Ritalin ©) (Dicesare *et al.*, 2005) and Naltrexone (Garcia & Smith, 1999).

The essence of an experimental functional analysis is its ability to directly identify functional relationships. The effects of stimulus conditions are measured precisely in a controlled environment that is routinely manipulated. This high degree of quantitative precision enables a demonstration of the associations between environmental stimuli and behaviours. These can be replicated to test hypotheses about the role of discriminative stimuli and establishing operations that occasion challenging behaviours. The approach is characterised by this systematic manipulation and its replicability. The empiricism of the method is its defining strength. However, despite these strengths, an experimental functional analytic approach has numerous limitations. There are practical, conceptual and ethical limitations associated with the technology.

The practical issues relate to the time, resources and expertise required to conduct analogue assessments. An epidemiological analysis of experimental approaches found that each assessment, on average, was conducted in six and a half hours over 26 sessions (Iwata *et al.*, 1994c). This means that analogue assessments may take up to several weeks to complete. Time is required to train staff to conduct complex analogue assessments and further time is

needed to prepare the analogue settings and analyse of the data. These pragmatic considerations may make an experimental functional analysis impractical in an applied clinical setting, especially in cases requiring urgent treatment (Durand & Crimmins, 1988). However, it has been claimed that analogue assessments are no more time consuming or complicated than descriptive assessment procedures (Iwata, 1994). The practical costs associated with implementing an experimental analysis are outweighed by the benefits that it brings (Lerman *et al.*, 1993). The increased rigour of such an analysis produces a more accurate assessment of function, which increases the likelihood of designing an efficient hypothesis-driven intervention programme (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Hagopian, Fisher, & Legacy, 1994). Nevertheless, the treatment validity of interventions derived from analogue assessment is not guaranteed.

There are conceptual problems associated with the experimental methodology that may undermine its findings. The validity of an experimental analysis can be threatened by various issues relating to the use of artificial conditions. The analogous conditions imposed may not represent the actual contingencies operating in the natural environment. Errors of omission may result if the stimuli controlling the target behaviour are not fully represented in the analogue conditions. The findings of an experimental approach may lack ecological validity and so may not generalise. It is therefore imperative that the analogue settings simulate the variables in the natural environment as closely as possible (Lennox *et al.*, 1989). A careful assessment of the natural environment is required to inform the selection of the analogue settings. One way of achieving this is to combine descriptive and functional analyses, thereby increasing the likelihood of identifying functional relationships operating in the natural environment (Mace & Lalli, 1991). Nevertheless, it is impossible for an analogous investigation to replicate all the dimensions of the natural environment (Mace & Shea, 1990). A contrasting type of error may also arise from experimental functional analyses. False positive findings may emerge in analogue conditions even though the motivational function implied has no parallel under natural conditions (Halle & Spradlin, 1993; Shirley, Iwata, & Kahng, 1999). Furthermore, it is possible that the sequence and timing of the analogue manipulations may inadvertently influence the likelihood of the target behaviours being evoked (Hains & Baer, 1989). One strategy for minimising carryover effects is to present analogue conditions in a predetermined manner (Iwata *et al.*, 1994b). However interaction effects may remain an unavoidable procedural artefact of multielement designs (Vollmer, Iwata, Duncan, & Lerman, 1993). The conditions that maintain challenging behaviours may be obscured by indistinguishable results (Vollmer, Marcus, & Leblanc, 1994). In such

circumstances, a reversal experimental design (Vollmer *et al.*, 1993) or a pair-wise test design (Iwata *et al.*, 1994b) may be adopted.

Experimental analysis methods have additional deficiencies that relate to the reinforcement contingencies under investigation. Standard analogue studies conditions omit to consider the possibility of tangible reinforcement as a function of challenging behaviour (Oliver & Head, 1993). Also, the test conditions for positive reinforcement are considered only in terms of social attention. However, it is possible to incorporate additional test conditions involving the presentation of food and materials, if the attention condition does not produce positive results (Iwata *et al.*, 1994b). Another serious shortcoming is that reinforcement processes are considered only in broad terms. The analyses can only demonstrate that behaviours are sensitive to a general class of reinforcement. They cannot highlight the specific reinforcer. This is problematic since specific features of reinforcement processes determine the extent to which behaviours are maintained (Carr, 1994). For instance, no specific test condition has been developed to assess escape from social interaction (Iwata *et al.*, 1994b). The negative reinforcement contingency is examined under test conditions that involve escape from demands. The assumption is that task demands are the aversive stimuli that provoke escape behaviours. In fact, it may be that the challenging behaviour serves specifically to escape from social contact (Taylor & Carr, 1992; Oliver, Murphy, Crayton, & Corbett, 1993). Social interaction may be the aversive stimulus that occasions the behaviour. Identifying the specific categories of stimuli that control behaviours has direct and important implications for treatment selection (Carr, Yarbrough, & Langdon, 1997; Lalli & Kates, 1998).

Experimental functional analyses have associated ethical implications. The purpose of assessments is to contrive changes in the target behaviour across different environmental conditions. This involves purposefully presenting the discriminative stimuli of the target behaviour. The justification for engendering challenging behaviour rests on the long-term therapeutic benefits brought about by this temporary increase in target behaviour. However, this question of free-responding is controversial when the target behaviour is frequent, intense or harmful. Another ethical issue relates to the potential risks of exposing the challenging behaviour to additional reinforcement processes. New associations may be learnt by introducing the behaviour to a novel reinforcement contingency (Iwata, Vollmer, & Zarcone, 1990). Supplementary functional relationships established during assessment then would be transferred into the natural environment.

2.2.5 *Structured Descriptive Assessments*

A structured descriptive assessment is a new technology that reconciles the conceptual and practical limitations of descriptive and experimental functional analyses. Aspects of the methodology from both approaches are integrated in a structured descriptive assessment. This hybrid approach has two defining features. First, it involves the systematic presentation of different classes of antecedent events, which have been shown to evoke challenging behaviour. This reflects the rationale of experimental functional analyses. However, unlike the experimental model, consequences are not manipulated and naturally occurring responses happen instead. Second, it is conducted in the natural environment by typical care providers, which resembles all descriptive analytical assessments.

The procedural basis of structured descriptive assessments was developed by Freeman, Anderson and Scotti (2000). They conducted functional assessments for two participants using a structured descriptive methodology, in addition to implementing an informal descriptive analysis and an experimental functional analysis. The frequencies of the environmental events recorded in both descriptive functional assessment methods were compared. Six classes of environmental events were measured. Three of these related to antecedent events (instruction delivery, attention removal, tangible removal) and three related to consequent events (attention delivery, instruction removal, tangible delivery). The structured descriptive assessment resulted in significantly more occurrences of these environmental events, particularly the antecedent events, in comparison with the unstructured descriptive analysis. Also, the outcomes identified in the structured descriptive assessment were then compared to those from the experimental functional analysis. The occurrence rates of challenging behaviour in the experimental conditions were contrasted across both assessments methods. The behavioural functions derived from both methodologies were congruent, for both participants.

This formative study indicated the potential utility of a structured descriptive assessment as a more efficient method of functional assessment. The findings of the study showed its efficiency in collecting data in comparison to more time-intensive unstructured descriptive analyses. In addition to this clinically beneficial feature, the study found that structured descriptive assessments produced accurate operant functions that resembled experimental techniques. Subsequent studies have investigated the technology further by conducting additional comparisons with experimental methods (Anderson & Long, 2002; English & Anderson, 2006) and by testing the effectiveness of interventions derived from it (Anderson *et al.*, 2002; Anderson, English, & Hedrick, 2006; English *et al.*, 2006).

Anderson and Long (2002) conducted structured descriptive assessments of four children in their school and home setting. The operant functions that emerged from the structured descriptive assessments matched those from the experimental functional analyses for three of the four participants. Treatment programmes were then designed on the basis of these hypothesised functions. This was done in three cases as the participation of one child was discontinued. The treatment for two participants consisted of one intervention because both assessment methodologies produced the same functional information. The treatments in both cases produced significant decreases in problem behaviour. For the other participant, for whom the assessments produced inconsistent results, the treatment was conducted in two phases. Each treatment phase matched the function derived from the corresponding method. Both phases were successful in reducing the problem behaviour, which indicated the behaviour served multiple functions.

English and Anderson (2006) also evaluated the treatment utility of structured descriptive assessments alongside experimental functional analyses, conducted independently by caregivers and experimenters. The hypotheses derived from the three methodologies regarding the maintaining variables of problem behaviours were mixed. Overall, a core element of consistent findings was recorded between the structured descriptive assessments and the caregiver-conducted analogues. Despite some concordance between the experimental functional analyses, differences in behavioural patterns emerged according to whether the analogues were by caregivers or experimenter. The treatment programmes that were implemented matched the function of the target behaviour as identified by the assessments. All treatments were consequence-based interventions that consisted of a single-component contingency manipulation. It was found that interventions based on the structured descriptive assessments were more effective than those based on either of the experimental functional analyses. However, treatment utility was not measured throughout because in some cases little or no problem behaviour occurred during the baseline of the relevant session.

These two studies (Anderson *et al.*, 2002; English *et al.*, 2006) indicated that structured descriptive assessments produce sufficient information to develop successful function-based treatments. Such positive evaluations of the effectiveness of treatments derived from the procedure have provided some measure of its internal validity. The ecological validity of the procedure is strengthened by the fact the procedure is conducted both in the natural environment and by typical caregivers. The finding that response patterns vary according to whether assessments are conducted by caregivers or clinicians has been reported elsewhere in the literature too (Sasso *et al.*, 1992; Ringdahl & Sellers, 2000). Given the differential effects of administrators on behaviour occurrence, the natural setting of the

assessment and the lack of response manipulation, structured descriptive assessment may offer a more accurate representation of naturally occurring contingencies. The external validity of structured descriptive assessments has been further supported by the application of the procedure and subsequent implementation of effective interventions with a typically developing population (Anderson *et al.*, 2006).

2.3 FUNCTIONAL ASSESSMENT METHODS APPLIED WITH THE BRAIN INJURY POPULATION

2.3.1 General Review

The neurorehabilitation field has been slow to embrace the practice of applied behaviour analysis (Mozzoni, 2000). The Overt-Aggression Scale – Modified for Neuro-rehabilitation (OAS-MNR) (Alderman, Knight & Morgan, 1997) is the only standardised functional assessment tool to be designed specifically for the brain injury population, as outlined in section 2.3.2. So, although the behavioural treatment model has been applied successfully for survivors of traumatic brain injury (Corrigan & Bach, 2005), clinical interventions based on prior functional assessments still remain limited (Ager & O'May, 2001).

A review of behavioural treatment studies over a 20 year period, from January 1988 until December 2007, found only eleven studies that had conducted a formal assessment of behavioural function (see Chapter 3). One study used the MAS to conduct an indirect functional assessment (Guercio & McMurrow, 2002). Four studies adopted a descriptive approach to functional assessment, by using ABC recording charts (Andrewes, 1989; Persel, Persel, Ashley & Krych, 1997; Yody *et al.*, 2000) and the MOAS-MNR (Alderman, 1991; Knight, Rutterford, Alderman & Swan, 2002). The other six studies used an experimental functional analysis (Pace, Ivancic, & Jefferson, 1994; Treadwell & Page, 1996; Ebanks & Fisher, 2003; Dixon *et al.*, 2004; Fyffe, Kahng, Fittro & Russell, 2004). These studies were the only ones to publish the data from the assessment.

During this period, a large number of studies ascribed behavioural function to the target behaviour but did not specify the assessment method used to make such assertions (Luiselli, 1994; Feeney & Ylvisaker, 1995; Alderman & Knight, 1997; Manchester, Hodgkinson, & Casey, 1997; Rothwell, LaVigna, & Willis, 1999; Hegel & Ferguson, 2000; Mozzoni & Hartnedy, 2000).

2.3.2 *Overt-Aggression Scale – Modified for Neuro-rehabilitation (OAS-MNR)*

The Overt Aggression Scale (OAS) is an observational questionnaire that seeks to record four categories of inappropriate behaviour: verbal aggression (VA); physical aggression against others (PA); physical aggression against objects (PO); and, physical aggression against self (PS). In addition to counting the number of incidences, the tool records the severity of the behaviour on a four-point scale. So, for instance a VA1 is a mild verbal outburst, whereas a PS3 is a severe form of self-injury. All behavioural categories are clearly defined. The OAS enjoys widespread use within the fields of adult psychiatry and learning difficulties. Alderman and colleagues (1997; 1999) have modified the scale specifically for use with a brain injured population and amended the terminology to suit users in the United Kingdom.

Alderman, Knight and Morgan (1997) outlined the revisions made to the OAS, which are in addition to some of the defining principles of the OAS (the four behaviour types and their severity ratings). The first significant change relates to the inclusion of antecedent recordings. Alderman and colleagues (1997) include two broad categories of antecedents in the OAS-MNR. The first group of antecedents refers to global environmental factors that may contribute to the behaviour, for instance, noisy environment, structured activity. The second range of antecedent categories relates to more specific behaviour events. These environmental antecedents can be engendered by staff, other patients or the patient. Each of the antecedent events are defined and numbered for ease of recording. For instance, visual feedback about performance; given direct verbal prompt to comply with an instruction; direct response to other clients physically aggressive behaviour when not directed at them; obviously agitated or distressed. The benefit of this method, which differs from standard ABC charts is that multiple antecedents can be recorded when occurring simultaneously. A similar category of recording is employed for the consequences following the behaviour. Here different ranges of interventions are defined and lettered, for ease of use, and examples provided. The OAS-MNR has amended and added some intervention categories in addition to the original. Again, multiple consequences are recorded in the order in which they occur.

Alderman and colleagues (1997) tested reliability by conducting independent observation conducted by two observers, both on the wards and via video recordings, and clinical notes. Using Kappa statistics, to correct for the degree of agreement occurring through chance, good agreement was achieved. Kappa scores above .93 were achieved for the classification of the behaviour types, their severity and the consequential interventions. However, the antecedent reliability was merely fair (.74). The authors then considered the reliability values for antecedent events when they occurred singularly and in multiples.

Although they found consistency in the recording of single antecedent events (.94), the recording of multiple antecedents was merely fair (.64). This indicates a potential weakness in the tool, especially as behaviours are often preceded by many events. Naturally occurring behaviours do not often take place in a clear, unitary A-B-C fashion. Indeed, the authors recorded 2½ times more multiple antecedent events than single ones. It is possible, then, in cases of a single recorded antecedent, there were in fact multiple antecedent events and they were missed or considered irrelevant to the behaviour. The OAS-MNR is a tool that relies on a subjective opinion as to the relevance of an antecedent. The opinion of separate observers can be incorrectly in agreement, especially if the antecedent precedes the behaviour by a comparatively long time. Moreover, in clinical settings, the tool is used as a reaction to a behaviour occurring. In response to the occurrence of behavioural outburst, observers may quickly turn to it and only catch the immediate antecedent of the event. If all relevant environmental stimuli are not accessible to recording then the validity of measure is undermined. By using the scale in this reactive manner, in a clinical environmental, the effectiveness of the measure to draw out contingencies may be limited. However, Alderman and colleagues (1999, 2002) effectively used the OAS-MNR to generate hypotheses of behaviour to drive treatment and monitor subsequent interventions, and also as part of a clinical audit.

2.4 SUMMARY

Indirect methods of functional assessment include clinical intuition, structured interviews, questionnaires or rating scales. These informant-based measures are advantageous as they can account for a wide range of environmental variables and are useful for assessing infrequently occurring challenging behaviours. Also, they are often used in clinical settings as they require little training and administration time. However, the data collected are retrospective and can be biased by inaccurate recollections or misperceptions. Consequently, the reliability and validity of indirect methods varies and can be poor.

Descriptive analysis methods assess function by directly observing naturally occurring interactions between challenging behaviours and social stimuli. Naturalistic observations do not involve any artificial manipulation of environmental conditions. Consequently, such methodologies have high ecological validity but provide correlational data only. Different techniques can be used to conduct a descriptive analysis but they vary according to the detail of output provided. The most basic forms describe the generate circumstances associated with the occurrence of challenging behaviour. More rigorous forms offer a descriptive narrative and provide basic information about the events that precede and

follow the target behaviour in a given situation. Sequential analysis methods are the most progressive kind of descriptive analysis. They depict how well past events predict future ones based on an analysis of probability. Sequential relationships between variables can be identified either by event- or time-based calculations.

An experimental functional analysis involves the systematic manipulation of environmental variables, in order to identify those that control and maintain the target behaviour. Experimental control is demonstrated when a change in conditions brings an associated change in the target behaviour. The effects of stimulus conditions are measured precisely in a controlled environment and can be replicated. The empiricism of this methodology is its defining strength. Nevertheless, experimental approaches have numerous practical, conceptual and ethical limitations. First, they require a great deal of time, resources and expertise. Second, the analogue testing conditions may not represent the actual contingencies operating in the natural environment. Also, reinforcement processes are considered only in broad terms meaning that specific reinforcers cannot be identified. Third, there are ethical implications associated with the purposeful presentation of stimuli in order to engender and maintain challenging behaviours.

The conceptual and practical limitations of descriptive and experimental functional analyses are reconciled in a structured descriptive assessment. This new technology is a hybrid that integrates aspects of the methodology from both approaches. Its first defining feature is that it involves the systematic presentation of different classes of antecedent events, which reflects the rationale of experimental functional analyses. However, unlike the experimental model, consequences are not manipulated and naturally occurring responses happen instead. The second defining feature is that it is conducted by typical caregivers in the natural environment, which resembles all descriptive analytical assessments. There is evidence to suggest that structured descriptive assessments enhance the outcome of behavioural interventions. As such, structured descriptive assessments provide an efficient and accurate way of conducting functional assessments of high clinical value.

The first empirical study of this thesis, presented in Chapter 3, follows on by investigating the effectiveness of behavioural interventions in treating challenging behaviours. A meta-analysis of treatment studies will be conducted, which will explicitly measure treatment outcomes following behavioural modification programmes. The study will also investigate whether functional assessments are necessary for a successful intervention programme.

CHAPTER 3 META-ANALYSIS

3.1 INTRODUCTION

Meta-analytic studies in the traumatic brain injury literature have focused on a number of different aspects of rehabilitation including neurorehabilitation in general, the effectiveness of different interventions at various phases in recovery and specific intervention strategies. These studies shall be summarised in this introduction. This shall provide an understanding on how this research study extends the meta-analytical literature on brain injury rehabilitation. The meta-analysis conducted in this study focuses on the effectiveness of behavioural interventions designed to reduce challenging behaviours shown by traumatic brain injury survivors.

The effectiveness of traumatic brain injury rehabilitation has been considered by a number of meta-analysis studies. Cope (1995) conducted a narrative review of the clinical efficacy and cost effectiveness of neurorehabilitation. The review was novel as it focused on treatment paradigms at successive phases of the rehabilitation process. Intervention programmes were considered across intensive care, acute (neurosurgical and inpatient) and post-acute (residential and outpatient) rehabilitation settings. Strong support was found for the assertion that comprehensive neurorehabilitation systems benefit both brain-injury survivors and society. Chesnut and colleagues (1999) conducted similar research that addressed five key questions pertaining to different recovery phases. The strength of evidence provided in the studies was categorised using a three-level classification system. Positive outcomes were found to be associated with both early intervention and long-term rehabilitative management, although such support was derived from the less robust studies. Cullen and colleagues (2007) also used a system to classify the power of evidence regarding the effectiveness of inpatient, community and vocational rehabilitation. The majority of intervention programmes were found to be supported by limited evidence.

Meta-analytical techniques have also been used to compare the effectiveness of neurorehabilitation with the rehabilitation of other populations. Rice-Oxley and Turner-Stokes (1999) contrasted the rehabilitation literature for brain injury and stroke survivors. The studies relating to the brain injury population differed prominently in terms of the very limited number of randomised controlled trials conducted. Despite the lack of powerful study designs, support was found for early intervention, intensity of rehabilitation and post-acute rehabilitation. Malec and Basford (1996) compared recovery outcomes of brain injury survivors receiving post-acute neurorehabilitation with those receiving either no treatment,

unspecified care or inpatient-only intervention. The study also examined the effectiveness of specific post-acute brain injury rehabilitation approaches. The utility of behavioural interventions, cognitive rehabilitation, vocational rehabilitation and pharmacotherapy was supported.

The effectiveness of neurorehabilitation has been considered for particular groups within the traumatic brain injury population. Comper and colleagues (2005) evaluated rehabilitation outcomes for those with mild traumatic brain injury. Various education strategies were found to increase psychosocial functioning, functional abilities and general post-concussive symptoms. No support was found for the utility of pharmacotherapy and cognitive rehabilitation. However, behavioural modification interventions were not considered due to the small number of studies examined. Teasell and colleagues (2007) reviewed the rehabilitation literature pertaining to those with moderate to severe brain injuries occasioned by both traumatic and non-traumatic causes. The majority of intervention studies were supported by limited evidence only. Laatsch and colleagues (2008) carried out a systematic review of studies concerned with the recovery of non-adult brain injury survivors. In this study, cognitive and behavioural treatments were considered specifically. Treatment outcomes were classified in terms of either statistical or clinical significance but no elaboration was provided on how such classifications were established. Behaviour modification studies that treated challenging or aggressive behaviours using a multicomponent approach were found to be effective overall. However, the effectiveness of specific elements of behavioural interventions was not evaluated.

A limited number of meta-analytical studies have focused specifically on the efficacy of specific treatment paradigms. As noted above, Laatsch and colleagues (2008) considered the effectiveness of behavioural and cognitive treatments in improving outcome for brain injury survivors. Carney and colleagues (1999) also conducted a systematic review of the effectiveness of cognitive rehabilitation strategies only. The potential benefits of cognitive rehabilitation were assessed in relation to health outcomes, employment measures and cognitive functioning. However, the effectiveness of cognitive rehabilitation approaches has not been fully evaluated due to an insufficient number of large scale outcome studies (Gordon *et al.*, 1992). Most of the outcome studies conducted lack rigour due to the small numbers of participants involved. Cicerone and colleagues (2000) conducted a systematic review of 171 studies of various cognitive rehabilitative approaches. It was found that the majority (63%) of articles were single case studies or clinical series without any controls. Only 20% were prospective cohort studies, retrospective case-control studies or clinical series with controls, which are more methodologically vigorous.

Other meta-analytical studies have examined intervention studies for particular symptoms and impairments suffered by traumatic brain injury survivors. Various studies have examined intervention research on executive function (Coelho, DeRuyter, & Stein, 1996; Cicerone *et al.*, 2000; Cicerone *et al.*, 2005; Kennedy *et al.*, 2008). Methodological weaknesses have limited the findings of some of these studies, either because a table of evidence was not provided (Cicerone *et al.*, 2000; 2005) or the evidence articles were not fully evaluated (Coelho *et al.*, 1996). The review conducted by Kennedy and colleagues (2008) improved on these studies. They adopted a qualitative and quantitative approach and also used effect size statistics to evaluate the treatments of specific cognitive abilities.

Only one meta-analysis conducted in the brain injury literature has examined the effectiveness of behavioural interventions. Ylvisaker and colleagues (2007) conducted a systematic review of behavioural treatments implemented with children and adult exhibiting behaviour disorders after traumatic brain injury. The present review extends their research. It offers a more specific and improved examination of treatment outcome by presenting a description of effect size. Ylvisaker and colleagues (2007) reported that all included studies found improvements in behavioural functioning following treatment. However, they did not conduct any systematic quantification of treatment outcome. This weakness is rectified in the present study, by measuring effect size in order to assess effectiveness more objectively. This analysis was conducted for both treatment and follow-up data. The present study contrasts in other ways to the review conducted by Ylvisaker and colleagues (2007). The present study focuses specifically on challenging behaviours and behavioural interventions only. In their review, Ylvisaker and colleagues (2007) examined studies that used positive behaviour interventions and support procedures combined with cognitive and executive system interventions. The present review focused only on behaviour modification treatments associated with traditional applied behaviour analysis. An additional contrast relates to the target behaviours considered in the reviews. Ylvisaker and colleagues (2007) included studies that sought to increase functional daily-living skills. The present review related to challenging behaviours only and included only those studies that targeted the decrease of such behaviours.

The aim of this meta-analysis was to conduct a systematic review of behavioural interventions implemented with survivors of traumatic brain injury. Its purpose was to evaluate the effectiveness of intervention strategies that used only behavioural procedures, in treating challenging behaviours. The areas of investigation in this study concerned: (i) the characteristics of the traumatic brain injury survivors who were treated, (ii) the types of interventions implemented, and, (iii) intervention outcomes. As part of the overall aims of this

meta-analytical study, an examination of the use of functional assessments was also conducted. The purpose of this analysis was to examine the extent to which behavioural interventions adopted a functional analytical approach and the effectiveness of pre-intervention functional assessments.

3.2 METHOD

3.2.1 *Search Procedure*

A comprehensive search of journal articles published in English over a 20 year period, between January 1988 and December 2007, was conducted. The following recognised bibliographic databases were searched: EMBASE, MEDLINE, PsychInfo and PsychArticles. The procedure of the literature search involved three preliminary steps. Each step related to the population, symptom and intervention. The first step involved the following search items: brain damage, head damage, brain injury, head injury, brain trauma, head trauma, ABI and TBI. The next step concerned the search terms: aggression, behaviour disorder, challenging behaviour. The last step included: intervention, management, rehabilitation, therapy and treatment. The searches in every step were conducted using the Boolean operator 'OR'. Truncation functions were also used to incorporate plural forms and variants with Americanised spellings. Finally, the outputs of each step were combined using the Boolean operator 'AND'. This process resulted in 1218 unique records.

An exclusionary screening process was conducted at the literature retrieval stage. This involved excluding records that were editorials, review articles, theoretical articles, qualitative case reports or pharmacological treatment studies. The title and abstract of each remaining record was then reviewed. In addition to the electronic bibliographic search, a manual inspection of the following journals was also conducted: *Brain Injury*, *Behavioural Interventions*, *Journal of Head Trauma Rehabilitation* and *Neuropsychological Rehabilitation*. To be included in this review, a study had to: (a) include at least one participant with a traumatic brain injury, (b) target challenging behaviour for treatment, (c) implement a behavioural modification procedure, as part of a psychological intervention strategy, (d) use an outcome measure based on formal observation, and, (e) report quantitative data.

3.2.2 *Data Collection*

The goal of the data abstraction process was to provide information about the study, participants, interventions and outcomes. Information from studies that included multiple participants or multiple treatments, which were implemented in one or more settings, were incorporated in the table of evidence. Data were collected along a number of specific

dimensions, as described below. These are represented in successive columns in the table of evidence, as shown in Table 3.1.

Study: The study's authors and the year of its publication were listed.

Design: The treatment design used in the study was stated. It was made clear if the study adopted separate designs for treating different participants or target behaviours.

Participants: For each participant, the following background information was stated, if possible: age, sex and time since injury onset. The information was listed separately if the study included multiple participants. Details concerning participants' function were limited to the most prominent facts. This may have included impairments in general intellectual, cognitive, executive or motor functioning. A footnote was used to indicate if the study included other participants who were excluded from this review. These participants were excluded because either they were not brain injury survivors or their targeted behaviour was a functional skill and not a challenging behaviour.

Target Behaviours: Only those behaviours targeted for intervention were stated. Other behaviours exhibited by the participant not pertaining to the dependent variable were not mentioned. All target behaviours related to one of four types of challenging behaviour: aggression, self-injury, destructiveness or disruption. These categories resemble those used in recent epidemiological studies of challenging behaviours (Emerson *et al.*, 2001; Lowe *et al.*, 2007). If available, the specific topography of the challenging behaviour was always noted. For aggressive behaviours the topography was specified as either a physical or verbal form of aggression. It was made clear whether the dependent variable was an amalgamation of multiple target behaviours or whether each behaviour was considered separately.

Functional Assessment: Any details regarding the presumed function of the target behaviour were recorded. A note was made of the method used to conduct the pre-intervention functional assessment. In some cases, function was stipulated without specifying the assessment method. It was also made clear whether any data regarding the functional assessment was included in the study.

Intervention Techniques: The intervention techniques used in the studies were recorded. In some cases multiple treatment strategies were implemented. For the purposes of data analysis, the following categories were used to group all implemented intervention techniques: (i) antecedent control procedures, (ii) contingency management, (iii) functional communication training, (iv) information feedback, (v) noncontingent reinforcement, (vi) punishment procedures, (vii) self-management, and, (viii) token economy. Antecedent control procedures were those that altered antecedent settings or modified the presentation of stimulus triggers. Contingency management included extinction as well as various forms of differential

reinforcement that are dependent on the occurrence of the target behaviour. Punishment procedures incorporated the use of physical restraint, response cost, social disapproval and time-out. Self-management related to behavioural contracting and self-monitoring techniques.

Duration / Setting: The context of the intervention was provided by recording the duration of the treatment phase, in terms of time or number of sessions, and the location where the treatment was implemented.

Reliability: Information regarding inter-observer reliability measures was documented. This included the total proportion of time observed by the second observer and the type of agreement calculation used. The resultant data (the agreement index and/or range) were also recorded, both in relation to the target behaviour and, where provided, staff / facilitator behaviours. Data pertaining to the agreement of non-occurrences were not explicitly stated but it was made clear which studies had published such data.

Outcome: Data were collected in order to evaluate the effectiveness of treatments. Treatment data were analysed to calculate the effect size of the outcome, as detailed in section 3.2.3. The resultant effect-size measurements were documented.

Maintenance: Information regarding the maintenance of treatment effects was extracted. This included the length of time after treatment termination and the number of occasions on which follow-up data were collected. All follow-up data were analysed using the delta statistic, as detailed in section 3.2.3. Effect size calculations measured the degree of difference between the baseline phase and the follow-up period only. This provided some measure of the long term treatment effects. If no follow-up data were provided, anecdotal claims of maintenance were still recorded.

3.2.3 Data Analysis

The focus of social science research continues to shift towards practical and/or clinical significance. Null hypothesis significance testing is being increasingly superseded or supplemented by statistics that measure the magnitude of treatment effects (Carver, 1993; Dar, Serlin, & Omer, 1994). Effect size provides a continuous criterion of outcome that is not unduly affected by sample size (Parker & Brossart, 2003). Effect size measurements quantify the degree of difference between two independent samples. This makes it especially useful for summarising the effectiveness of single-subject studies (Busk & Marascuilo, 1992). The technique then is particularly pertinent for behaviour analysts who mostly conduct clinical studies using some variant of the AB format. Also, by offering a standard metric, effect size can be used to integrate the results of multiple studies, making it the most basic unit of evaluation in meta-analytic research (Allison & Gorman, 1993).

Various measures of effect size have been proposed (Kirk, 2007). Many have evolved from that originally proposed by Cohen (1969; cited in Kirk, 1996), which represents the difference in sample means in standard deviation units. In this calculation the difference between the mean of the experimental group and the mean of the control group is determined and then divided by the pooled estimate of their common standard deviation. Subsequent measures have adopted alternative approaches to standardising the mean difference (see, Keselman, Algina, Lix, Wilcox, & Deering, 2008) but no uniformly appropriate standardiser exist. Despite being widely used, most forms of effect size based on the standardised mean differences are sensitive to violations of parametric assumptions (Kraemer & Andrews, 1982; Hedges & Olkin, 1984).

Under such circumstances, of variance heterogeneity and non-normality, regression-based approaches (e.g., Gorsuch, 1983; Center, Skiba, & Casey, 1985; White, Rusch, Kazdin, & Hartmann, 1989; Allison *et al.*, 1993) are better alternatives (Strube, Gardner, & Hartmann, 1985; Parker *et al.*, 2003). However, there are three main issues associated with regression-based models that can potentially limit their findings. The first is the issue of autocorrelation of time-series datum points (Crosbie, 1993; Robey, Schultz, Crawford, & Sinner, 1999). Another concerns the fact that regression-based models assess effect size at one interruption in the time-series, i.e. at a single combination of an A and B phase. There is no consensus on a procedural solution that can accommodate single-subject studies with several interruptions or those using alternative procedures, such as multiple baseline and alternating treatment designs (Allison *et al.*, 1993). The most significant concern relates to decreasing baseline trends obscuring the real effectiveness of the treatment and preventing an accurate appraisal of the true effect size. This problem is prevented if the baseline period is of adequate length for stability to be established. However, most clinical studies do not report enough baseline datum points for regression techniques to be applied meaningfully.

In light of these limitations, non-parametric indices of effect size were used in this review. The first benefit of a non-parametric index is that effect size can be gauged using only a small number of datum points (Kraemer *et al.*, 1982). This makes it relevant for a review of clinical studies, of which the majority use a single-subject design, with a limited number of datum points in the baseline and treatment phases. Effect size calculations were calculated in this study using at least three datum points, in both the baseline and treatment phase. The other benefit of a non-parametric index is that its only assumption is independence (Romano, Kromrey, Coraggio, & Skowronek, 2006) and it is more robust to violations of normality (McGraw & Wong, 1992). Consequently, the use of non-parametric testing for meta-analysis research has been recommended (Kraemer & Kupfer, 2006). Two non-parametric indices

were used in this study, the delta statistic (Cliff, 1993; 1996) and the Percentage of Nonoverlapping Data (PND) (Scruggs, Mastropieri, & Casto, 1987).

The delta statistic (δ) (Cliff, 1993; 1996) examines the probability that individual scores in one group are likely to be greater than scores in the other group. As described below (see, Hess & Kromrey, 2004), the population parameter is the probability that a randomly selected member of one population has a higher response than a randomly selected member of the second population, minus the reverse probability:

$$\delta = \Pr(x_{i1} > x_{j2}) - \Pr(x_{i1} < x_{j2}) \quad [1]$$

where; x_{i1} is a member of population 1, x_{j2} is a member of population 2.

The sample estimate is obtained by enumerating the number of times scores within group 1 have a greater value than the scores within group 2, and the number of occurrences of the reverse:

$$\hat{\delta} = \frac{\#(x_1 > x_2) - \#(x_1 < x_2)}{n_1 n_2} \quad [2]$$

where; x_1 is the scores within group 1, x_2 is the scores within group 2, n_1 is the sample size of group 1, n_2 is the scores within group 2.

The approach provides an ordinal index of association. The delta statistic is based on the concept of stochastic difference, which involves the direct comparison of all the members of both populations (Delaney & Vargha, 2002). So, given calculations are not based on a comparison of means, the measure is appropriate regardless of the heterogeneity of variances (Kromrey, Hogarty, Ferron, Hines, & Hess, 2005). The delta statistic has been advocated for meta-analytical research (Kraemer *et al.*, 2006), in preference over parametric tests of mean difference (Parker, 1995; del Rosal, San Luis, & Sanchez-Bruno, 2003).

The PND examines the proportion of nonoverlapping data scores between two conditions. It is calculated by percent of datum points in the treatment phase that exceed the lowest baseline datum point (Campbell, 2004). In cases with multiple baselines, and identical treatment procedures, the PND is calculated by enumerating the treatment datum points in relation to the preceding baseline and then summing the individual scores (Scruggs & Mastropieri, 1998). The PND is pertinent for the analysis of single-case designs and provides an intuitive representation of effects. Despite the fact that it has been widely used, the utility of the PND metric may be limited by the presence of outliers in the baseline or trends in the data. Still, this nonparametric statistic is not strictly an effect size measure but serves to indicate the extent to which an effect is believable (Herzinger & Campbell, 2007). In this study the PND was used as an adjunct to the delta statistic.

3.3 RESULTS

Thirty-eight studies satisfied the inclusion criteria. All the studies included at least one participant with a traumatic brain injury, targeted challenging behaviour for treatment, implemented a behavioural modification procedure, as part of a psychological intervention strategy, used an outcome measure based on formal observation and reported quantitative data. However nine of these studies (24%) were not included in the review because the data provided were not amenable to measurements of treatment outcome. These nine studies either provided indecipherable graphed data or insufficient data to evaluate outcome. Details of the excluded studies are provided in Appendix A.

So, analysis was conducted on the remaining 29 behavioural treatment studies. These met the inclusion criteria and also yielded quantitative measures for the effectiveness of their treatments. The table of evidence is shown in Table 3.1. The results related to the study participants, interventions and outcomes, as discussed in section 3.2.2. A total of 53 participants were represented across all the studies. Sixteen studies (55%) applied interventions to single participants and thirteen studies (45%) related to multiple participants.

Table 3.1 Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Andrewes (1989).	Single subject, baseline-intervention design.	F., 32 yrs old, profound impairment of intellectual functioning, extremely poor communication skills.	Screaming.	ABC recording chart: behaviour considered to be positively reinforced by receiving social attention.	Differential reinforcement of other behaviour, extinction, time out.	34 days. Residential rehabilitation unit.	Not reported.	.87 / 82.4%	3 month follow-up, 1.00
Zencius, Wesolowski and Burke (1989).	Single subject, multiple baseline, reversal design.	[P1] M., 16 yrs old. [P2] F., 16 yrs old.	Noncompliance.	Not reported.	Behavioural contract, cues, token economy, along with response cost.	[P1] 57 days. [P2] 44 days. Residential rehabilitation unit.	Not reported.	[P1] .89 / 73.2% [P2] .85, 93.0%	Anecdotal claims, after 2 months [P1] / after 1 month [P2], that rates were maintained successfully.
Zencius, Wesolowski, Burke and McQuade (1989).	Single subject, baseline-intervention design [P1] / Single subject, multiple baseline, reversal design [P2].	[P1] M., 24 yrs old, 6 yrs post-injury, impaired cognitive abilities, hemiparesis. [P2] F., 24 yrs olds, 2 yrs post-injury, impaired cognitive abilities, hemiparesis [Other study participant was excluded.]	[P1] Absconding behaviours. [P2] Noncompliance.	Not reported.	[P1] Behavioural contract, cues. [P2] Behavioural contract, cues, differential reinforcement of alternative behaviour, token economy.	[P1] 17 days. [P2] 37 days. Residential rehabilitation unit.	Not reported.	[P1] .82 / 52.9% [P2] .59 / 50.0%	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Alderman (1991).	Single subject, multiple baseline design.	M., 24 yrs old, 6 yrs post-injury, pervasive memory deficits, extremely poor communication skills, wheelchair user.	Verbal aggression.	Overt Aggression Scale Modified for Neuro-Rehabilitation – behaviours considered to be negatively reinforced by escaping demands.	Extinction, time out, token economy, along with response cost.	20 sessions. Residential rehabilitation unit.	Not reported.	.53 / 70.0%	Not reported.
Slifer, Cataldo, Babbitt, Kane, Harrison and Cataldo (1993).	Single subject, multiple baseline, across-subjects design.	[P1] M., 10yrs old, 36 days post-injury. [P2] M., 10 yrs old, 32 days post-injury. [P3] M., 15 yrs old, 12 days post-injury.	[P1] Noncompliance, verbal aggression [combined]. [P2] Noncompliance. [P3] Noncompliance, verbal aggression [combined].	Not reported.	Differential reinforcement of alternative behaviour, extinction, token economy, with incremental expectations along with response cost.	[P1] 29 days. [P2] 11 days. [P3] 16 days. Residential rehabilitation unit.	Not reported.	[P1] .96 / 95.8% [P2] 1.00 / 100% [P3] .93 / 93.8%	Anecdotal claims, after 2 weeks [P1] / after 1 month [P3], that rates were maintained successfully; [P2] Anecdotal claims, after 1 month, that rates returned to former levels.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Davis, Turner, Rolider and Cartwright (1994).	Single subject, multiple baseline design.	M., 23 yrs old, 1 yr post-injury, severely impaired cognitive and executive abilities.	Physical aggression, verbal aggression [combined].	Not reported.	Cues, differential reinforcement of other behaviour, with incremental changes in the reinforcement schedule, prompts, social disapproval.	52 days Residential rehabilitation unit.	25% of data, percentage agreement was 91% (range, 78-100%), and 86% (range, 76-98%) for facilitator behaviours.	.53 / 0%*	6 month follow-up, 0.75
Kennedy (1994).	Single subject, multiple baseline, reversal design.	M., 20 yrs old, 5 yrs post-injury, profound impairment of intellectual functioning, quadriplegia. [Other study participants were excluded.]	Physical aggression, throwing / hitting objects [combined].	Descriptive structured analysis of antecedent conditions, manipulated in non-naturalistic settings.	Antecedent control (changing demand levels).	30 sessions. Special education facility.	25% of data, percentage agreement was 89% (range, 33-100%), and 93% (range, 78-100%) for facilitator behaviours [+ data for non-occurrence].	.91 / 62.1%	4 month follow-up, 0.85
Luiselli (1994).	Single subject, multiple baseline, across-settings design.	F: 8 yrs old, 2 yrs post-injury, extremely poor communication skills, hemiparesis.	(a) Object grabbing, (b) Object mouthing.	Unspecified – behaviours considered to be positively reinforced by receiving social attention.	Noncontingent reinforcement of appropriate sensory stimulus.	(i) Morning: 14 days. (ii) Afternoon: 9 days. Special education centre.	8% of data, percentage agreement was 100%. (i)(a) .76 / 50.0% (i)(b) .80 / 0%* (ii)(a) .89 / 66.7% (ii)(b) 1.00 / 100%	(i)(a) .76 / 50.0% (i)(b) .80 / 0%* (ii)(a) .89 / 66.7% (ii)(b) 1.00 / 100%	Follow-up conducted but insufficient data provided to measure outcome.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Pace, Ivancic and Jefferson (1994).	Single subject, reversal design.	M., 49 yrs old, <1 yr post-injury.	Swearing, verbal aggression [combined].	Experimental functional analysis [+ data.] – behaviour considered to be negatively reinforced by escaping demands.	Antecedent control (demand fading).	26 sessions. Specialist residential setting.	57% of data, percentage agreement was 80%, and 94% for facilitator behaviours [+ data for non-occurrence].	1.00 / 100%	Not reported.
Alderman, Fry and Youngson (1995).	Single subject, reversal design.	F., 21 yrs old, profound impairment of intellectual functioning, pervasive memory deficits.	Perseverations.	Not reported.	Token economy, along with response cost.	34 sessions. Residential rehabilitation unit.	Not reported.	.59 / 60.0%	Follow-up conducted but insufficient data provided to measure outcome.
Feeney and Ylvisaker (1995).	Single subject, reversal design.	[P1] M., 19 yrs old, 5 yrs post-injury, extremely poor communication skills. [P2] M., 18 yrs old, 3 yrs post-injury, hemiparesis. [P3] M., 18 yrs old, 5 yrs post-injury, impaired executive abilities.	Physical aggression, verbal aggression [combined].	Unspecified – behaviours considered to be negatively reinforced by escaping academically-related work demands.	Antecedent control (picture cues, task sequencing and difficulty, verbal cues), behavioural contract.	[P1] 22 sessions. [P2] 22 sessions. [P3] 20 sessions. Special education centre.	20% of data, mean percentage agreement was 80%	[P1] .98 / 95.5% [P2] .97 / 95.5% [P3] .99 / 95.2%	Anecdotal claims that rates were maintained successfully.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Slifer, Cataldo and Kurtz (1995).	Single subject, multiple baseline across-settings, reversal design.	F., 8 yrs old, agitation, pervasive memory deficits, extremely poor communication skills.	Screaming, noncompliance, verbal aggression [combined].	Not reported.	Differential reinforcement of alternative behaviour, token economy.	(i) Physical therapy: 38 sessions; (ii) Occupational therapy: 20 sessions. Inpatient treatment facility.	8% of data, percentage agreement was 99% (range, 95-100%) for screaming, 96% (range, 85-100%) for noncompliance and 98% (range, 85-100%) for verbal aggression.	(i) .88 / 92.1% (ii) .46 / 0%*	Not reported.
Slifer, Tucker, Gerson, Cataldo, Sevier, Suter and Kane (1996).	Single subject, baseline-intervention design [P1, P2] / Single subject, multiple baseline, across-subjects design [P3, P4, P5] / Single subject, multiple baseline design [P6].	[P1] M., 8 yrs old, 77 days post-injury. [P2] F., 10 yrs old, 42 days post-injury. [P3] F., 12 yrs old, 48 days post-injury. [P4] M., 12 yrs old, 70 days post-injury. [P5] M., 16 yrs old, 68 days post-injury. [P6] M., 10 yrs old, 28 days post-injury.	[P1] Noncompliance. [P2] Physical aggression, throwing / ripping objects [combined]. [P3] Absconding behaviours. [P4] Screaming. [P5] Physical aggression, throwing / hitting / ripping objects [combined]. [P6] Noncompliance.	Not reported.	Differential reinforcement of alternative behaviour, extinction, token economy, with incremental expectations along with response cost.	[P1] 8 sessions. [P2] 7 sessions. [P3] 21 sessions. [P4] 6 sessions. [P5] 21 sessions. [P6] 15 sessions. Inpatient treatment facility.	[P1, P2, P4 & P6] 9% of data, mean percentage agreement was 90% (range, 79-100%). [P3 & P5] 54% of data, mean percentage agreement was 100%.	[P1] .96 / 87.5% [P2] .86 / 85.7% [P3] .63 / 0%* [P4] .56 / 0%* [P5] .61 / 0%* [P6] .98 / 93.3%	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Treadwell and Page (1996).	Single subject, baseline-intervention design [P1] / Single subject, alternating treatment design [P2].	[P1] M., 37 yrs old, 13 yrs post-injury. [P2] M., 3½ yrs old.	[P1] Physical aggression, property destruction, self-injury, verbal aggression [combined]. [P2] Physical aggression, self-injury, verbal aggression [combined].	Experimental functional analysis [+ data.] – [P1] behaviours considered to be negatively reinforced by escaping demands. [P2] behaviours considered to be positively reinforced by receiving social attention and tangible items.	[P1] Guided compliance, behavioural momentum & extinction. [P2] Functional communication training, for (i) social attention and (ii) tangible items, and extinction.	[P1] 23 sessions. [P2] 12 sessions. Specialist residential setting.	Not reported.	[P1] .83 / 91.7% [P2] (i) .68 / 0%* (ii) .56 / 23.1%	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Alderman and Knight (1997).	Single subject, baseline-intervention design [P1] / Single subject reversal design [P2] / Single subject, multiple baseline, across-behaviours design [P3].	[P1] M., 58 yrs old, 2 yrs post-injury, pervasive memory deficits, hemiparesis. [P2] F., 35 yrs old, 3 yrs post-injury, moderate impairment of intellectual functioning. [P3] M., 33 yrs old, 7 yrs post-injury, pervasive memory deficits.	[P1] (a) Inappropriate sexual behaviours, (b) Physical aggression, (c) Swearing, (d) Verbal aggression. [P2] Verbal aggression. [P3] Verbal aggression.	Unspecified – behaviours of all participants considered to be negatively reinforced by escaping demands.	Differential reinforcement of low rates of responding, token economy, with informational feedback.	[P1] (a) 30 sessions (b) 58 sessions (c) 44 sessions, (d) 42 sessions. [P2] 32 sessions. [P3] 56 five-day blocks. Residential rehabilitation unit.	Not reported	[P1] (a) 1.00 / 100% (b) .78 / 82.7% (c) .87 / 41.0% (d) .63 / 42.9% [P2] .84 / 67.9% [P3] .41 / 64.3%	[P1] Follow-up data, collected at four stages, not amenable to analysis. [P2] 5 month follow-up, 0.73. [P3] Not reported.
Manchester, Hodgkinson and Casey (1997).	Single subject, baseline-intervention design.	M., 24 yrs old, 1yr post-injury, profound impairment of intellectual functioning, poor communication skills.	Noncompliance. [Other behaviours were excluded – no baseline data reported.]	Unspecified – all behaviours considered to be positively reinforced by receiving tangible items and negatively reinforced by escaping demands.	Differential reinforcement of other behaviour, extinction, token economy, along with response cost.	31 weeks. Specialist residential setting.	Not reported.	.85 / 86.2%	Anecdotal claims, after 10 months, that rates were maintained successfully.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Persel, Persel, Ashley and Krych (1997).	Single subject, reversal design.	M., 40 yrs old, 13 yrs post-injury, severely impaired cognitive abilities.	(a) Physical aggression, (b) Head-banging.	ABC recording chart and scatterplot – behaviours considered to be positively reinforced by receiving social attention.	Noncontingent reinforcement delivered on fixed-time interval, positive punishment (restraint).	9 weeks. Residential rehabilitation unit.	Interval-by-interval agreement was 97%.	(a) .44 / 22.2% (b) .71 / 55.6%	Follow-up conducted but insufficient data provided to measure outcome.
Rothwell, LaVigna and Willis (1999).	Single subject, baseline-intervention design.	[P1] M., 33 yrs old, 2 yr post-injury. [P2] F., 42 yrs old, 2 yrs post-injury.	[P1] Physical aggression. [P2] (a) Physical aggression, (b) Verbal aggression.	Unspecified – [P1] behaviour considered to be negatively reinforced by escaping aversive environment. [P2] behaviours considered to be positively reinforced by receiving social attention.	Functional communication training and training of functionally related skills.	[P1] 24 weeks. [P2] 17 weeks. Residential rehabilitation unit.	Not reported.	[P1] .88 / 0%* [P2] (a) .88 / 72.7% (b) .51 / 50.0%	[P1] Not reported. [P2] Anecdotal claims, after 1 year, that rates were maintained successfully.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Schlund and Pace (1999).	Single subject, multiple baseline, across-subjects design.	[P1] M., 33 yrs old, 4 yrs post-injury, impaired cognitive abilities. [P2] M., 27 yrs old, 9 yrs post-injury, impaired cognitive abilities. [P3] M., 48 yrs old, 4 yrs post-injury, impaired cognitive abilities.	[P1] Physical aggression, verbal aggression [combined]. [P2] Inappropriate sexual behaviours, physical aggression, verbal aggression [combined]. [P3] Noncompliance.	Not reported.	Antecedent control (feedback).	[P1] 11 weeks. [P2] 9 weeks. [P3] 7 weeks. Inpatient treatment facility.	Not reported.	[P1] .43 / 0%* [P2] .37 / 0%* [P3] .70 / 0%*	Not reported.
Hartnedy and Mozzoni (2000).	Single subject, multiple baseline, across-subjects, reversal design.	[P1] F., 6 yrs old, <1 yr post-injury, impaired cognitive abilities, extremely poor communication skills. [P2] F. 16yrs old, <1yr post-injury, severely impaired cognitive.	Noncompliance.	Not reported.	Antecedent control (decreasing environmental stimulation, minimum eating demands).	[P1] 22 days. [P2] 16 days. Residential rehabilitation unit.	Not reported.	[P1] .98 / 0%* [P2] .91 / 0%*	[P1 & P2] Anecdotal claims, after 6 months, that rates were maintained successfully.
Hegel and Ferguson (2000).	Single subject, multiple baseline design.	M., 28 yrs old, 10 yrs post-injury, extremely poor communication skills.	Physical aggression, verbal aggression [combined].	Unspecified – behaviours considered to be positively reinforced by receiving social attention.	Differential reinforcement of other behaviour, with incremental changes in the reinforcement schedule.	48 days. Residential rehabilitation unit.	Not reported.	1.00 / 100%	Follow-up conducted but insufficient data provided to measure outcome.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Mozzoni and Hartnedy (2000).	Single subject, alternating treatments design.	M., 15 yrs old, 14 yrs post-injury, severely impaired cognitive abilities.	Disruptive behaviours.	Unspecified – behaviour considered to be positively reinforced by receiving attention and negatively reinforced by escaping demands.	(i) Differential reinforcement of alternative behaviour, (ii) earned escape with incremental changes in the reinforcement schedule, (iii) information feedback.	(i) 43 sessions, (ii) 5 sessions, (iii) 6 sessions. Residential rehabilitation unit.	Not reported.	(i) 1.00 / 100% (ii) .99 / 97.7% (iii) .75 / 50.0%	Not reported.
Yody, Schaub, Conway, Peters, Strauss and Helsinger (2000).	Single subject, baseline-intervention design.	M., 48yrs old at injury onset, impaired cognitive abilities.	(a) Absconding behaviours, (b) Physical aggression, (c) Verbal aggression.	ABC recording chart – behaviours considered to be positively reinforced by receiving social attention.	Differential reinforcement of other behaviour, extinction, noncontingent social reinforcement, token economy, with informational feedback.	3 months. Residential rehabilitation unit.	Not reported.	(a) .63 / 0%* (b) -.19 / 0% (c) .02 / 0%*	Not reported.
Guercio and McMorrow (2002).	Single subject, baseline-intervention design.	M., 20yrs old, extremely poor communication skills.	(a) Inappropriate sexual behaviours, (b) Physical aggression, (c) Property destruction.	Motivation Assessment Scale – behaviours considered to be positively reinforced by receiving social attention.	Differential reinforcement of alternative behaviour, token economy.	18 weeks. Residential rehabilitation unit.	Not reported.	(a) .76 / 72.2% (b) .74 / 77.8% (c) .74 / 61.1%	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Knight, Rutterford, Alderman and Swan (2002).	Single subject, reversal design [P1, P2] / Single subject, alternating treatments design [P3].	[P1] M., 19 yrs old, 5 yrs post-injury, pervasive memory deficits. [P2] F., 44 yrs old, 5 yrs post-injury, pervasive memory deficits. [P3] M., 53yrs old, 13 yrs post-injury, severely impaired executive abilities.	[P1] Verbal aggression. [P2] Perseveration. [P3] Stereotypical comments.	Overt Aggression Scale Modified for Neuro-Rehabilitation – no clear outcomes emerged.	[P1] [P2] Differential reinforcement of low rates of responding. [P3] (i) Differential reinforcement of low rates of responding (ii) self-monitoring training.	[P1] 14 weeks. [P2] 6 weeks. [P3] (i) 8 sessions. (ii) 36 sessions. Residential rehabilitation unit.	Not reported.	[P1] .99 / 92.9% [P2] 1.00 / 100% [P3] (i) .97 / 87.5% (ii) .52 / 19.4%	[P1] Follow-up conducted but insufficient data provided to measure outcome. [P2] Immediate, 4 week and 5 month follow-up, 1.00, 1.00 and 1.00, respectively; [P3] Immediate follow-up, 1.00
Ebanks and Fisher (2003).	Single subject, alternating treatments design.	M., 19 yrs old, profound impairment of intellectual functioning.	Property destruction.	Experimental functional analysis [+ data.] – behaviour considered to be negatively reinforced by escaping demands.	(i) Consequent feedback. (ii) Antecedent control (modelling, praise, prompting).	(i) 10 sessions. (ii) 6 sessions. Inpatient treatment facility.	41% of treatment data, percentage agreement was 98%. 43% of experimental functional analysis data, percentage agreement was 99%.	(i) .90 / 0%* (ii) .90 / 0%*	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Dixon, Guercio, Falcomata, Horner, Root, Newell and Zlomke (2004).	Single subject, reversal design.	[P1] M., 20 yrs old. [P2] M., 48 yrs old. [P3] M., 61 yrs old. [Other study participant was excluded.]	[P1] Verbal aggression. [P2] Inappropriate sexual behaviour, verbal aggression [combined]. [P3] Verbal aggression.	Experimental functional analysis [+data] – [P1, P3] behaviour considered to be negatively reinforced by escaping demands. [P2] behaviour considered to be positively reinforced by receiving social attention.	Differential reinforcement of alternative behaviour.	[P1] 7 sessions. [P2] 13 sessions. [P3] 10 sessions. Inpatient treatment facility.	25% of treatment and experimental functional analysis data, percentage agreement was 93% (range, 88-100%).	[P1] .81 / 85.7% [P2] 1.00 / 100% [P3] 1.00 / 100%	Not reported.
Fyffe, Kahng, Fittro and Russell (2004).	Single subject, reversal design.	M., 9yrs old, poor communication skills, wheelchair user.	Inappropriate sexual behaviours.	Experimental functional analysis [+data.] – behaviour considered to be positively reinforced by receiving social attention.	Extinction, functional communication training, differential reinforcement of other behaviour, with incremental changes in the reinforcement schedule.	31 sessions. Inpatient treatment facility.	50% of treatment data, percentage agreement was 89% (range, 75-98%). 38% of experimental functional analysis data, percentage agreement was 95% (range, 94-95%).	.77 / 0%*	Not reported.

Table 3.1 (cont.) Table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Mottram and Berger-Gross (2004).	Single subject, multiple baseline, across-subjects design.	[P1] M., 8yrs old, moderate impairment of intellectual functioning. [P2] M., 6 yrs old, poor communication skills. [P3] M., 14 yrs old, profound impairment of intellectual functioning.	Disruptive behaviours.	Not reported.	Behavioural contract, differential reinforcement of other behaviour, token economy, along with response cost.	[P1] 33 sessions. [P2] 27 sessions. [P3] 20 sessions. Special education facility.	50% of data, percentage agreement was 96% (range, 91-100%).	[P1] 1.00 / 100% [P2] 1.00 / 100% [P3] 1.00, 100%	Immediate follow-up. [P1] 1.00 [P2] 1.00 [P3] 1.00

3.3.1 *Participant Characteristics*

Age- and sex-related data were provided in all studies. Three-quarters (75.5%, $n = 40$) of the sample were men. The mean age of the sample was 24.0 years ($SD = 14.8$). The age range was 3½ years to 61 years of age. In total, 40% ($n = 21$) of participants were below 18 years old, 47% ($n = 25$) were adults below the age of 45 years and 13% ($n = 7$) were 45 years old or over. Data relating to the time since injury onset were provided for 64% ($n = 34$) of participants. Of these, 27% ($n = 9$) had been brain injury survivors for three months or less, 6% ($n = 2$) for between four and twelve months, 41% ($n = 14$) for between one and five years and 27% ($n = 9$) for over five years.

The target behaviour for 57% of participants ($n = 30$) was a single challenging behaviour topography. The remaining participants exhibited multiple topographies that were targeted for treatment. The target behaviour in 74% of these cases ($n = 17$) was an amalgamated variable that represented all the multiple challenging behaviours collectively. In contrast, for the other 26% of these cases ($n = 6$), each challenging behaviour topography exhibited was treated as a distinct dependent variable. Consequently, across all 53 participants, a total of 63 target behaviours were subject to behavioural interventions. All target variables were assigned to one of five challenging behaviour categories; aggression, self-injury, property destruction, disruption and inappropriate sexual behaviour. Including those comprising amalgamated variables, 51% of target behaviours ($n = 32$) included at least one form of aggression and 46% of target behaviours ($n = 29$) represented at least one kind of disruptive act. Property destruction occurred for 10% ($n = 6$) of target behaviours, self-injury for 6% ($n = 4$) and inappropriate sexual behaviours for 8% ($n = 5$). Of the target behaviours in the aggression category, 44% ($n = 32$) related to just verbal aggression, 28% ($n = 9$) to just physical aggression and 28% ($n = 9$) to both verbal and physical aggression. The disruption category was represented by 13 cases of noncompliance (45%), 3 cases of absconding (10%) and 3 cases of screaming (10%).

3.3.2 *Intervention Types*

Single subject experiments were used in all studies. Designs that comprised a basic treatment versus baseline comparison (AB design) were implemented for 12 participants (23%). The following, more robust, single subject treatment designs were also recorded: reversal design ($n = 13$, 25%), alternating treatment design ($n = 4$, 8%), and multiple-baseline design ($n = 24$, 45%). The most common multiple-baseline variant incorporated either an across-subjects design or a reversal design.

For 54% of participants the duration of the treatment phase was not reported and could not be calculated from the data. Of those reported, the average duration of treatment was nine weeks. The duration was greater than four weeks for 78% of participants.

Sixteen studies (55%) conducted interventions within residential rehabilitation units. The other settings for the treatment studies were: inpatient treatment facilities ($n = 6$; 22%), special education facilities ($n = 4$, 15%) and specialist residential setting ($n = 3$, 11%)

Interobserver reliability was calculated for 41% ($n = 29$) of implemented treatments. Across these studies, the mean duration of independent interobserver measures as a proportion of the total session time was 29% ($SD = 17$, range from 8% to 57%). Maintenance of effects was reported for 48% ($n = 34$) of treatments. Of these, 32% ($n = 11$) provided only anecdotal claims of maintenance.

Across the total number of treatments implemented, over a third of cases (35%, $n = 25$) did not report the use of pre-intervention functional assessment. In 30% of cases ($n = 21$) a behavioural functional was stated but no information was given as to how it was assessed. Only 25 treatments (35%) were based on some explicitly specified functional assessment technique. Of these, 40% of treatments ($n = 10$) used an experimental functional analysis, 56% ($n = 14$) used a descriptive assessment and 4% ($n = 1$) used a structured descriptive assessment of antecedents. The ABC recording chart was the most commonly reported ($n = 6$) descriptive assessment method, followed thereafter by the OAS-MNR ($n = 5$) and the MAS ($n = 3$), as described in sections 2.2.3 and 2.3.2. All studies that used an experimental methodology provided functional assessment data. No such data were provided elsewhere.

A unitary treatment strategy was used in 42% of cases ($n = 30$). Of these, contingency management techniques ($n = 9$) and antecedent control procedures ($n = 8$) were most commonly used. Functional communication training was used in five cases and noncontingent reinforcement techniques were used in 4 cases. Of the cases that adopted a multicomponent intervention approach, a combination of two procedures was used in 29% of cases ($n = 12$), three procedures in 24% of cases ($n = 10$) and four or more procedures in 46% of cases ($n = 19$). The most common strategies using two treatment procedures in combination was differential reinforcement with token economy ($n = 5$) and antecedent control procedures with behavioural contracts ($n = 4$). Only one study integrated antecedent control and contingency management procedures. Token economy techniques were implemented along with differential reinforcement procedures in 72% of cases ($n = 28$).

Some form of punishment was used in 30% ($n = 21$) of all implemented treatments. Punishment techniques were always implemented in conjunction with other treatments and never as the unitary procedure. The most commonly used punishment technique was response

cost, which was used in conjunction with token economy treatments. Response cost represented 81% of all punishment techniques used. Physical restraint, social disapproval and time-out procedures were used with four participants.

3.3.3 *Treatment Outcomes*

The (positive) delta scores across all implemented treatments ranged from .52 to 1.0, with a mean value of .78 ($SD = .23$). All recorded values of the delta statistic were positive except for one. In this case the implemented treatment had a negative effect on outcome, with a negative delta score ($-.19$) and a zero PND score. There were an additional 17 cases in which a zero PND score was also found. However, these zero scores only emerged because of an outlier in the baseline condition. Such cases have been highlighted with an asterisk in the table of evidence, as shown in Table 3.1. Excluding these instances, the mean PND score was 72% ($SD = 29.97$). A correlational analysis found that the delta statistic and the PND score were not independent. The relationship between both outcome measures was found to be strong and positive ($r(52) = .78; p < .001$).

As shown in Table 3.2, treatments implemented as the sole intervention strategy were generally found to be equally effective. Aside from self management procedures ($\bar{x} = .52$), the mean effect size of outcomes across treatment strategies were similar, ranging from .70 to .99. Using published thresholds for the delta statistic (Vargha & Delaney, 2000), all treatment outcomes for unitary behavioural interventions were classified as strong. Of these, contingency management ($\bar{x} = .96$) and token economy treatments ($\bar{x} = .99$) were the most effective. However, the strength of these findings is limited given the small number of studies. The effectiveness of some of these treatments was found to change when they were applied in conjunction with other (unspecified) treatments. Self-management techniques appeared to be more effective when implemented in combination with other strategies ($\bar{x} = .52$ vs. $\bar{x} = .87$). Some treatments were more effective when applied alone, such as contingency management ($\bar{x} = .96$ vs. $\bar{x} = .78$), noncontingent reinforcement ($\bar{x} = .86$ vs. $\bar{x} = .56$), and token economy ($\bar{x} = .99$ vs. $\bar{x} = .74$).

The effectiveness of treatments that employed punishment techniques or functional assessments was not found to be different to those that did not. Treatment outcome was not significantly higher ($t(69) = -.17, p > .05$) in the punishment group ($\bar{x} = .77$) compared to the non-punishment group ($\bar{x} = .77$). Similarly, treatments based on functional assessments and those that did not implement a pre-intervention functional assessment did not significantly differ in their treatment outcome ($t(69) = .03, p > .05$).

Table 3.2 Effectiveness of behavioural treatments implemented either alone or in conjunction with other treatments

Treatment Design	Applied as The Sole Intervention Strategy			Applied in Conjunction With Other Treatments		
	n	Delta Statistic			Delta Statistic	
		Median	Mean	SD	Mean	SD
Antecedent control procedures	8	.91	.78	.25	.80	.21
Contingency management	9	1	.96	.08	.78	.26
Functional communication training	5	.68	.70	.17	.71	.16
Information feedback	2	.83	.83	.11	.83	.11
Noncontingent reinforcement	4	.85	.86	.11	.56	.40
Punishment procedures	0	–	–	–	.80	.19
Self-management	1	.52	.52	–	.87	.17
Token economy	1	.99	.99	–	.74	.28

3.4 DISCUSSION

The aims of this meta-analysis were to evaluate the effectiveness of the use of behavioural interventions in the peer reviewed published brain injury literature. This review focused only on behavioural modification treatments associated with tradition applied behavioural analysis. The effectiveness of treatment studies that targeted the decrease of challenging behaviours was investigated. Overall, the outcome of behavioural interventions was found to be effective, except in one reported case.

Three-quarters of participants were men. This ratio of 3:1 corresponds to established findings in the brain injury literature regarding the sex of survivors (Murray *et al.*, 1999; Kraus *et al.*, 2005; Tagliaferri *et al.*, 2006). The age distribution of participants in this review was found to be skewed with non-adult survivors representing 40% of participants. The age-specific results in this review were in line with the generally accepted finding that an

overrepresentation of young traumatic brain injury survivors exists (Hawley *et al.*, 2003; Wittenberg *et al.*, 2004; Tennant, 2005). In these respects, the participants in the evidence studies accurately represented the traumatic brain injury population. The time since injury onset for participants varied greatly. Two-thirds of participants had sustained their injuries for over a year when treatment commenced. This finding supports other studies that have found behavioural disturbances continue or intensify with time (Jennett, 1996; Lippert-Gruner *et al.*, 2006). Over a quarter of participants were very recent survivors of brain injury. The application of behavioural interventions with this group seems valid, in line with other studies that have found behavioural learning during the posttraumatic amnesia phase can occur (Slifer *et al.*, 1996).

The target treatment variable for over half of the participants consisted of a single challenging behaviour topography. The remainder of the participants exhibited multiple topographies that were targeted for treatment. However, in three quarters of these cases the target variable was an amalgamation of all the topographies combined. This approach to assessment is problematic as it assumes all the components of the amalgamated target variable are functionally equivalent and adhere to the same behavioural contingencies equally. Of all the targeted behaviours, half included at least one form of aggression. The presence of self-injury and inappropriate sexual behaviour was uncommon amongst participants.

Single subject experiments were used in all the studies in this review. This finding is typical in behavioural research where small-*n* experimentations are commonly used (Elmes, Kantowitz, & Roediger, 2006). However, a fifth of the evidence articles adopted a basic treatment-intervention design that is considered weak as it does not implement any control conditions. Reported outcome effects cannot be directly attributed to the treatment because the results may have been confounded by extraneous factors or spontaneous remission. The large proportion of such studies with poor internal validity affects the impact of the findings of this review. Nevertheless, the fact these studies have been published in peer-reviewed journals lends some credence to their status as evidence based research. The remainder of studies used more robust treatment designs, with nearly half adopting a multiple-baseline design and a quarter using reversal techniques.

Over half of the interventions implemented did not report the duration of the treatment phase. Of those reported, the average duration of treatment was nine weeks. Most interventions were conducted within residential rehabilitation units and inpatient treatment facilities. Only a quarter of treatments were implemented in special education facilities and specialist residential settings. It is of note that few studies in this review have been conducted in non-treatment settings. This small body of evidence lends little support for the

generalisation of behavioural interventions. It is difficult to establish the effectiveness of behavioural-based interventions with only limited evidence of the transfer of treatment effects to non-treatment conditions.

Over a third of interventions were not based on a prior functional assessment. Another third of interventions claimed to have established the function of target behaviour but did not specify any details regarding the assessment conducted. The finding that only a limited number of interventions were based on an explicitly specified functional technique is not unusual in the traumatic brain injury literature (Ager & O'May, 2001). The review findings indicate that calls for the neurorehabilitation management to be driven by an integrated model of behavioural analysis have not been heeded (Yody *et al.*, 2000; Mozzoni, 2000). The use of functional assessments in the brain injury literature is extremely limited compared to other population groups. As mentioned in section 2.1, functional assessment procedures have been increasingly applied with other populations, as the basis for behavioural treatment (Pelios, Morren, Tesch, & Axelrod, 1999; Kahng, Iwata, & Lewin, 2002). Nevertheless, the results of this review found no difference in outcome between treatments that employed functional assessment and those that did not. This contrasts with the generally accepted notion that functional assessments are an influential factor in the effectiveness of behavioural interventions (Iwata *et al.*, 1994b; Didden, Korzilius, van Oorsouw, & Sturmey, 2006). However, this finding does not necessarily mean that functional assessments do not enhance behavioural interventions. It does mean that some behavioural interventions were designed on the basis of clinical intuition, which resulted in the correct behavioural function being determined. Nevertheless, clinical intuition cannot supersede formal functional assessment procedures in the identification of the function of challenging behaviours. Still, in order to accurately assess the merits of an applied behaviour analytic approach, randomised controlled trials are needed to establish a meaningful comparison.

Nine studies were excluded from this review because their reported data did not permit the calculation of effect size of treatment outcome. This problem has been identified by many authors who have recommended a standard protocol for reporting outcome measures (Scotti, Evans, Meyer, & Walker, 1991b; High, Boake, & Lehmkuhl, 1995; Malec & Basford, 1996; Rice-Oxley & Turner-Stokes, 1999; Gurdin, Huber, & Cochran, 2005; Comper, Bisschop, Carnide, & Tricco, 2005; Cullen, Chundamala, Bayley, & Jutai, 2007). From the included evidence articles, all implemented interventions, apart from one, were reported to have yielded positive treatment outcomes. The average effect size across all interventions was strong. A unitary treatment approach was used in over 40% of studies. The effectiveness of all

treatments implemented via a single treatment procedure was found to be equal. However, the effectiveness of these treatments changed when applied in combination with other treatments.

Despite reported effectiveness the behavioural intervention outcome were reported for all interventions, apart from one, maintenance was reported for only half of these interventions. Furthermore, a third of these cases offered anecdotal evidence of maintenance only without data. The paucity of follow-up assessment is of concern. Other meta-analyses of brain injury rehabilitation have also reported a lack of follow-up data (Carney *et al.*, 1999). The inconsistent reporting of maintenance is a methodological concern for a significant proportion of the evidence articles. Future studies of behavioural interventions for the brain injury population should provide reliable and valid measures of treatment gains. An accurate appraisal of behavioural intervention success cannot be made without consistent reporting of maintenance and, as discussed above, generalisation.

Another common methodological weakness of many evidence articles was the absence of interobserver reliability measurements. This review found that interobserver reliability calculations were only reported for 41% of implemented treatments. Moreover, in all cases reliability was calculated using a percentage agreement index. This approach is limited by its tendency to over estimate agreements level, as it does not account for agreements that would have happened by chance. A more conservative interobserver agreement index, like the Kappa (κ) coefficient (Cohen, 1960), was never used. Nevertheless, where reported, the obtained percentage agreement values were adequate, in most cases. The duration of assessments conducted by a second observer ranged from 8% to 57% of the total time. Again, inconsistent reporting of interobserver reliability undermines any meaningful interpretation of the evidence base.

Aside from the methodological concerns of the evidence articles, this study has a number of limitations. First, reliability of data extraction was not conducted. No independent investigators were used to classify the article studies in this review. However, this limitation was not too significant as the inclusion criteria were unambiguous. A more serious limitation, which is typically associated with all meta-analytical research, concerns sample bias. The effect of sample bias is that the data extracted may be unrepresentative in terms of either the direction or size of effects. This is a possible likelihood given that publications tend to report only positive findings (Strube *et al.*, 1985). Consequently inferences drawn from this single subject meta-analysis may not generalise to the general population. In fact, the problem is even demonstrated in some of the evidence articles in this review. A number of studies stated that unsuccessful treatment attempts had been implemented prior to the behavioural intervention under investigation (Zencius, Wesolowski, & Burke, 1989; Zencius,

Wesolowski, Burke, & McQuade, 1989; Alderman, 1991; Alderman, Fry, & Youngson, 1995; Persel *et al.*, 1997; Yody *et al.*, 2000; Hegel & Ferguson, 2000; Guercio *et al.*, 2002; Knight, Rutterford, Alderman, & Swan, 2002). Brief anecdotal details of the failed procedures were given in some studies but none provided any explicit data.

The overall finding of this meta-analysis is that behavioural interventions are effective in treating challenging behaviours exhibited by survivors of traumatic brain injury. This indicates that challenging behaviours adhere to the operant behaviour hypothesis. The aim of the second empirical study, presented in the next chapter, was to explore for evidence to support the notion that challenging behaviours are in fact operants. This view has been substantiated extensively in the intellectual disabilities literature but not in the field of traumatic brain injury. This second empirical study was a descriptive analysis designed to test whether challenging behaviours were occasioned and/or maintained by social contingencies.

CHAPTER 4 DESCRIPTIVE ANALYSIS

4.1 INTRODUCTION

Survivors of traumatic brain injury suffer a range of problems, as outlined in section 1.6. Neuropsychological deficits are of the most significant obstacles to achieving a successful rehabilitative outcome (Freeman, 1999). Positive neuropsychiatric conditions encompass behavioural excesses, such as physical aggression, verbal aggression, self-injury, agitation and sexual disinhibition. Different models for the treatment of such challenging behaviours exist, as described in section 1.7. The approach of the dominant medical paradigm is based on pharmacological management. Some neuropsychiatric symptoms may be alleviated by medication. However, in practice, multiple medications are prescribed at high doses and this leads to further adverse neuropsychiatric reactions (Silver *et al.*, 2005). The effectiveness of cognitive remediation approaches, which view cognitive impairments as the underpinning cause of challenging behaviours, has been supported. However, a certain degree of cognitive competence is a prerequisite to engage in these strategies in the first place. So, the applicability of cognitive rehabilitation may be limited to those with less severe forms of brain injury only.

It has been argued, in section 1.7.3, that learning-based models of intervention are applicable for all brain trauma survivors irrespective of injury severity. Moreover, such behavioural approaches have been shown to be especially effective for survivors of moderate to severe brain injury (Wood, 1988). The behavioural approach has been used predominantly, in both research and clinical practice, to understand and modify challenging behaviours (Emerson, 2001). The approach is based on principles of operant conditioning. Undesirable behaviours are decreased using procedures that employ reinforcement, extinction, punishment and stimulus control. The effectiveness of such behaviour modification procedures is, arguably, enhanced by conducting an accurate assessment of the controlling variables of challenging behaviour. As mentioned in the introduction to Chapter 2, the scientific study of human behaviour (applied behaviour analysis) is characterised by the systematic identification of the environment conditions that occasion and maintain challenging behaviour (functional assessment). The goal of functional assessment methods is to identify the causal functional relationships between the challenging behaviours and environmental events. Only then can behaviours be modified successfully by, for instance, teaching alternative and more adaptive functionally equivalent responses (Carr *et al.*, 1985). Functional assessments have been applied extensively in the field of learning disabilities for some time (e.g., Iwata *et al.*, 1982;

1994a; Carr, 1994; Derby *et al.*, 1994; Oliver, 1995). In stark contrast, the application of applied behaviour analysis generally, and functional analysis specifically, to the area of neurorehabilitation is comparatively recent (Mozzoni, 2000).

Both the theoretical and clinical application of functional assessments with the brain injured population is limited. There have been strong calls for comprehensive management plans for brain injury survivors to be developed through an integrated model of behaviour analysis (Yody *et al.*, 2000). Clinically relevant functional assessments are needed as an ongoing process to drive regular changes in treatment plans. Most of the functional assessments conducted with brain-injured clients have adopted an experimental design (Iwata *et al.*, 1982; 1994a). Although considered by most behaviour analysts as the pinnacle of the functional assessment hierarchy, experimental functional analysis has limitations. Also, most of the experimental functional analysis studies in the brain injury literature have been single case studies that have focused on single target behaviours only (Pace *et al.*, 1994; Dixon *et al.*, 2004; Fyffe *et al.*, 2004). Only one such study has investigated multiple topographies of challenging behaviour (Treadwell *et al.*, 1996). In this study, the behaviours were amalgamated into one category and then the combined variable was analysed. All interpretations derived from findings of an aggregated behaviour must be made with caution (Derby *et al.*, 1994).

In the brain injury field, functional assessments have been conducted using a descriptive analysis methodology, as covered in section 2.2.3. However, they have been limited in terms of detail and validity. Response scatter-plots have been used to provide an event based narrative of the contexts surrounding the target behaviour (Persel *et al.*, 1997). Retrospective incident records have been used to gauge the influence of restraint with young people (Luiselli, Pace, & Dunn, 2003). The OAS-MNR (Alderman, Knight, & Morgan, 1997) has been applied as a retrospective account of the antecedents and consequences of challenging behaviours. Behaviour-recording charts have been used also to formulate treatments plans for elopement (Yody *et al.*, 2000). The findings of all these treatment studies have lacked robustness. The assessment methods were retrospective, and so susceptible to subjective biases, and the dependent measures expressed merely in terms of frequency (Luiselli, Dunn, & Pace, 2005). A more thorough form of descriptive analysis can be provided by conducting continuous and live recordings. Behaviour monitoring charts, similar to the ABC chart (Bijou, Peterson, & Ault, 1968), have been used. This method has been adopted in a single case study that evaluated treatment conditions using a reversal design (Persel *et al.*, 1997). However, the data were collected using a crude 15-minute interval recording technique and no formal analysis of the antecedents and consequences were reported.

The superior methods of descriptive analysis are those that have used electronic technology to record behaviours and analyse data (Repp *et al.*, 1989). To date no studies have used a comprehensive observational technique to conduct this type of functional assessment with the brain injury population. In the present study, participant and staff responses were recorded live on a handheld computer using observational software (Martin, Oliver, & Hall, 2001). All behaviours were observed in their naturalistic environments. The technology allowed multiple variables to be documented simultaneously in continuous time. The software facilitated a very detailed degree of analysis. The protocol adopted to record the variables was an important feature of the study. Instead of coding challenging behaviour generally by its topography, all individual forms of behaviour were recorded as distinct units. This enabled the analysis to be specific in terms of the behaviour form (e.g. kicking, punching) and also global at a topographical level (e.g. physical aggression). Furthermore, the analysis was conducted in relation to separate topographies. In this way the findings were not limited by combining topographies to form an aggregated challenging behaviour variable (Derby *et al.*, 1994). Another innovative aspect of the recording protocol was the coding of different types of challenging behaviour. Primary challenging behaviour types were conceptualised as those behaviours traditionally considered as aggressive (physical aggression, property destruction, self-injury, verbal aggression). In addition to these, other problematic behaviours were also recorded. These were undesirable responses that needed to be reduced but which were only a long-term clinical objective. These less prominent behaviours were referred to as secondary challenging behaviours. Both challenging behaviour types were considered in the study.

The purpose of this study was to conduct a thorough descriptive analysis of challenging behaviours. Its aim was to explore contingencies of challenging behaviours and ascertain whether they were functional. This was achieved by conducting a detailed assessment of behavioural function to: (i) investigate whether challenging behaviour types and environmental events were associated, and, (ii) investigate whether a mutual reinforcement hypothesis was applicable between challenging behaviours and the environmental events.

4.2 METHOD

The study was granted ethical approval by Northampton Primary Care Trust, as shown in Appendix B.

4.2.1 *Participants*

4.2.1.1 *Selection and Recruitment*

Participants were patients recruited from a specialist unit of a hospital in the United Kingdom. The unit offered rehabilitation services to adult survivors of acquired brain injury. The inclusion criteria for participant selection were comprehensive. Brain injured patients whose behaviour hindered rehabilitation or influenced daily management were considered for selection. This was determined through a consultative process with staff. Inclusion was not based on the type or severity of the brain injury or the form or intensity of the exhibited behaviour.

The patients who were eligible for inclusion in the study were identified during regular multidisciplinary team meetings. Their suitability to participate was evaluated thereafter by the Responsible Medical Officer and the Staff Nurse. Recruitment to the study was formally approved by the Responsible Medical Officer. Those able to give informed consent were approached directly for their agreement to participate. The nature of the study was discussed with them. They were read a simplified information sheet and given a consent form, as shown in Appendix C. If they agreed to participate, they were informed of their imminent involvement shortly prior to the observations beginning. At this stage they were reminded of their right to withdraw. Legal assent was sought on behalf of the participants who were unable to consent for themselves. The assenting advocate was their next of kin or the Responsible Medical Officer, if the participant did not have family. The relative was posted a letter, an information sheet and a consent form, as shown in Appendix D.

Fifteen participants were recruited for the study. Eleven of them were detained under the Mental Health Act 1993. The remaining four participants were voluntary patients and were the only participants deemed to have the capacity to consent. All participants, except for three of the voluntary patients, resided in a locked facility of an acute ward. All participants presented with multiple topographies of challenging behaviour.

4.2.1.2 *Participant Attrition*

The observational recordings of six participants were terminated prematurely. Two participants showed considerable reactivity to the observation. Their reactions were so great that the validity of the data would have been compromised. Another two participants exhibited challenging behaviours too infrequently for any meaningful analyses to be conducted. The other participants exercised their rights to withdraw from the study. The details of these prematurely terminated observations are presented in Table 4.1.

Table 4.1 Prematurely terminated observations

Participant	Total Observation Time	Number of Sessions	Proportion Observed by Second Observer	Reason for Termination
A	20min	2	0%	High reactivity
B	1hr, 31min	3	20.5%	High reactivity
C	1hr, 45min	2	60.3%	Infrequent occurrence
D	2hr, 4min	5	32.8%	Infrequent occurrence
E	2hr, 24min	5	42.6%	Withdrew
F	3hr, 50min	7	34.8%	Withdrew

4.2.1.3 Study Participants

Complete observational data were collected and analysed for nine participants. Personal details and information regarding their brain injury are presented in Table 4.2. The time-specific information provided in the table was accurate on the first day the participant was observed.

The participants' functional abilities and their brain injury severity are presented in Table 4.3. The information on participants' abilities was derived from informal observations and not from standardised tests. The severity of brain injury was measured at the time of trauma, using one of two classification systems, as discussed in section 1.4.2. Severity measures were available for three participants only and the index reported was the Glasgow Coma Scale (GCS).

Table 4.2 Demographic and brain injury details

Participant	Sex	Occupation	Education Level	Age (yr, mth)	Time since Admission (yr, mth)	Time Since Injury (yr, mth)	Causes of Injury	Type of Injury
1	M	[Information unavailable, in electronic version.]	[Information unavailable, in electronic version.]	42, 5	0, 3	1, 2	Road traffic accident	–
2	F			31, 11	1, 0	7, 5	Viral infection; herpes simplex	Cerebral encephalitis
3	M			38, 2	0, 6	6, 1	Single-vehicle accident; motorcycle	Subarachnoid haemorrhage, frontal subdural haematomas, brain oedema, bilateral temporal contusions, increased intracranial
4	M			26, 1	2, 0	4, 1	Suicide attempt by hanging	Hypoxic brain damage
5	M			29, 8	1, 4	3, 7	Sporting accident	Low-density lesions in the corda nuclei bi laterally and left internal capsule
6	M			59, 6	0, 2	1, 1	Road traffic accident; pedestrian	Contusions to parietal, occipital and temporal lobes
7	M			46, 3	0, 1	2, 2	Road traffic accident	Chronic subarachnoid haemorrhage, cerebral contusion in right front temporal region, mild hydrocephalus
8	M			30, 5	1, 3	3, 3	Road traffic accident	Right sided frontal haemorrhage, right thalamic haemorrhage, cerebral oedema, extensive soft tissue swelling
9	F			51, 8	0, 11	8, 5	Sporting accident	Intracerebral haemorrhage in the right temporal region, some subdural haemorrhage, mild hydrocephalus

Table 4.3 Injury severity and functional abilities

Participant	Severity Index	Understands Simple Sentences	Articulates Speech	Physically Mobile	Able to Self Care	Controls All Bodily Functions
1	4/15 (GCS)	✓	✓	–	–	–
2	n.a.	✓	–	✓	–	–
3	n.a.	✓	–	–	–	–
4	n.a.	✓	✓	✓	✓	✓
5	9/15 (GCS)	✓	–	✓	–	–
6	n.a.	✓	✓	–	–	–
7	n.a.	✓	–	–	–	–
8	n.a.	✓	✓	–	–	✓
9	7/15 (GCS)	✓	✓	✓	✓	✓

Key:

n.a. data not available

✓ participant has competence in that ability

– participant can not demonstrate that functional ability

4.2.2 Procedure*4.2.2.1 Coding Techniques*

Data were collected using observation software on a handheld personal computer. The software used, for both the collection and analysis of observational data, was ObsWin (Martin *et al.*, 2001). A Windows CE version of the program was run on a Hewlett Packard Jornada 690. This version was capable of simultaneously recording up to 46 mutually exclusive variables in real time. All variables were recorded by depressing keys on the computer keyboard. Each key was assigned to a different variable. The keys were allotted using colour-coded labelled stickers.

The coding scheme adopted for all participants was broadly identical. As such the layout of the keyboard remained largely constant across all observations. The coding scheme used to record participant and staff behaviours was mostly fixed and unchangeable. The coding of all primary challenging behaviours topographies was done using the same keys. The coding scheme was only different for the secondary challenging behaviour topographies. These behaviours were idiosyncratic. So, the keyboard layout differed from participant to participant. The operational definitions of all recorded variables are detailed in section 4.2.3. Catch-all keys were used to record unforeseen variables, which had not been allocated a key

beforehand. Three catch-all keys were used in total. One was assigned to mark any coding errors or unexpected incidents. The details of these were dictated quietly into a voice recording device.

The coding scheme was established in advance. All variables were defined either as an event or duration variable. An event variable was a momentary variable that occurred within one time interval. The onset time of an event variable matched its offset time. Event variables were recorded by depressing the key once to mark its occurrence. A duration variable was a lengthy variable that spanned multiple time intervals. The onset time of a duration variable differed to its offset time. Duration variables were recorded by depressing the key to mark its onset and then again to indicate its offset.

Some behaviours were recorded as event variables even though they were durational variables by nature. This practice was applied to some of the staff member's verbal behaviours, which are discussed in section 4.2.3.3. Each verbal statement made by staff was recorded as an event variable. This coding technique was adopted to enhance accuracy, by removing any doubt as to when a staff member's speech would terminate. Each sentence verbalised was recorded as an event variable. Then prior to the analyses, as discussed in section 4.2.4.1, all 'event' variables that occurred within a specific time window were combined to create one duration variable. Similar procedures for recording occurrences of participant behaviours have been conducted in other studies (Dixon, Benedict, & Larson, 2001; Dixon *et al.*, 2004).

4.2.2.2 *Naturalistic Observations*

Preliminary observations were conducted with all participants prior to any formal data collection. These observations were a preparatory exercise to practice the experience of real recordings. This activity was similar to a pilot study. The data collected were not analysed in the study. The observers were introduced to some of the behaviours and interactions that were likely to be exhibited. They were able to discuss any possible coding issues and agree on the operational definitions. The pilot also served to eliminate participants' reactivity to the observations before any actual study data were collected.

In addition to the preliminary observations, other measures were taken to enhance the validity of the study data. The formal observations were conducted as covertly as possible. The observers constantly repositioned themselves to be in the most unobtrusive location. This was often away from the direct view of the participant. Whenever possible the observers blended in with staff and other patients. Actions also were taken to minimise the reactivity of staff to the observations. The aims of the study were made clear to the staff. They were

assured anonymity and informed which of their behaviours were being recorded. All staff members were urged to interact with their patients normally. They were instructed not to engage with the observers or seek any assistance from them.

The details of the observation sessions conducted for each participant are presented in Table 4.4. Over 152 hours of observational data were recorded for the study. On average each participant was observed for nearly seventeen hours and the mean length of each observation session was 75 minutes. The total observation time and the duration of each observation session was not determined by any formal criteria. Observational recordings were ceased when it was judged that the data collected was sufficient for meaningful findings to emerge.

Table 4.4 Observation details

Participant	Total Time (hr, min)	Number of Days Taken to Complete	Frequency of Observation Sessions	Average Duration of Observation Session (hr, min)
1	12, 55	14	22	0, 35
2	17, 36	4	9	1, 57
3	9, 41	9	14	0, 42
4	25, 15	7	15	1, 40
5	19, 12	7	13	1, 29
6	24, 17	6	11	2, 12
7	19, 41	10	22	0, 54
8	15, 16	22	24	0, 38
9	8, 44	6	8	1, 5
Mean	16, 57	9.44	15.33	1, 15
SD	5, 52	5.53	5.96	0, 36
Range	8, 44 / 25, 15	4 / 22	8 / 24	0, 38 / 2, 12

4.2.2.3 Social Setting Activities

The participants were observed in various social settings throughout the therapeutic week (Monday–Friday, 8.30am–5.00pm). During these times participants were engaged in

different activities. Their daily schedule determined whether they would be engaged in, for example, a group activity, an unstructured activity, mealtime or a therapeutic activity. The operational definitions of these social setting activities are presented in Table 4.5. The social settings were mutually exclusive and exhaustive. They were recorded as a durational background code using a catch-all key.

Observations were conducted on a quasi-random basis. Morning hygiene programmes were often targeted for observation. During these times most participants exhibited high levels of aggression. Additional data were collected either before or after the morning hygiene programme. Usually if participants were observed during breakfast then the observation session continued until the end of their morning hygiene activity. If an observation session began with the hygiene programme then typically observations continued until the end of lunch. Often a second observation session was conducted in the afternoon. This covered either lunch or dinner if a mealtime activity had not been observed previously in the day. Generally participants were observed during one mealtime each day. Aside from the morning hygiene programmes and mealtimes, the observed activities were arbitrary. The activities scheduled for the participants were not known beforehand. Their daily schedule did not influence when or how the observation sessions were conducted. The extent to which each participant was observed in each social setting activity is presented in Table 4.6. The entire observation time in each social setting is shown along with the proportion of the total.

Table 4.5 Operational definitions of social setting activities

Social Setting Activity	Operational Definition
Group activity	Engaging in a structured group activity. For instance: bingo, karaoke, a quiz, a group information session, an educational lesson.
Hygiene programme	Being supervised to conduct personal hygiene activities in the morning. This includes showering in the bathroom, changing and grooming in the bedroom.
Intervention	Receiving some form of medical, hygienic or practical intervention. For instance: administering medicine, testing blood sugar levels, being changed, being peg fed.
Mealtime	Receiving a meal (breakfast, lunch, dinner) that the participant is expected to consume. Mealtime does not include eating snacks, which is optional.
Seclusion	Being forcibly placed in an isolation room or relocated away from others in a situational time-out.
Therapeutic activity	Engaging in a structured activity with a direct rehabilitative purpose. For instance: physiotherapy, a speech and language session, an occupational therapy activity.
Unstructured activity	Engaging in a recreational activity either alone or with others. For instance: reading, looking at photographs, watching television, playing cards, listening to music.

Table 4.6 Observation details: Social setting activities

Participant	Group Activity (hr, min)	Hygiene Programme (hr, min)	Intervention (hr, min)	Mealtime (hr, min)	Seclusion (hr, min)	Therapeutic Activity (hr, min)	Unstructured Activity (hr, min)
1	0, 30 3.9%	4, 1 31.1%	0, 12 1.6%	3, 12 24.8%	–	3, 21 26.0%	1, 38 12.6%
2	–	0, 22 2.1%	0, 28 2.6%	1, 58 11.2%	–	–	14, 49 84.2%
3	0, 28 4.8%	4, 10 43.0%	1, 7 11.5%	0, 34 5.8%	0, 40 6.9%	0, 16 2.7%	2, 27 25.3%
4	1, 41 6.7%	0, 5 0.3%	0, 3 0.2%	1, 52 7.4%	–	1, 26 5.7%	19, 51 78.7%
5	0, 19 1.6%	2, 5 10.8%	0, 27 2.3%	0, 52 4.5%	0, 8 0.7%	0, 47 4.1%	14, 35 76.0%
6	–	2, 33 10.5%	1, 59 8.2%	1, 43 7.1%	–	0, 14 1.0%	17, 48 73.3%
7	–	3, 49 19.4%	0, 53 4.5%	–	1, 12 6.1%	1, 55 9.7%	11, 52 60.3%
8	–	6, 13 40.7%	0, 2 0.2%	1, 34 10.2%	0, 29 3.2%	3, 7 20.5%	3, 51 25.2%
9	–	0, 29 5.6%	–	1, 46 20.2%	0, 11 2.2%	–	6, 18 72.1%
Total	2, 58	23, 46	5, 5	13, 30	2, 43	11, 6	93, 3

4.2.3 Observer Agreement and Response Definitions

4.2.3.1 Interobserver Agreement

A second observer collected data independently of the primary observer. Their data were not analysed in the study but used only to gauge agreement between observers. The details of the observations conducted by the second observer are presented in Table 4.7. On average, the second observer collected data during 25.7% (range 17.3% to 54.6%) of the total observation time.

Table 4.7 Observation details: Second observer

Participant	Total Observation Time (hr, min)	Observation Time as a Proportion of the Total Time (%)
1	7, 3	54.6
2	3, 2	17.3
3	2, 4	21.3
4	5, 20	21.1
5	5, 37	29.2
6	4, 56	20.3
7	4, 17	21.7
8	3, 32	23.2
9	1, 57	22.3
Mean	4, 12	25.7
SD	1, 37	10.65
Range	2, 4 / 7, 3	17.3 / 54.6

The agreement between the observers was calculated using Kappa (κ) coefficient (Cohen, 1960). A comprehensive description of different agreement indices and the rationale for using Kappa coefficient is provided in Appendix E. The agreement measures were calculated on a three second interval-by-interval basis. Agreement was deemed to have occurred if both observers recorded the same event within the same three second time window. This small tolerance level diminished some of the effect caused by dissimilarities in observers' reaction times (Murphy, 1987; Hall & Oliver, 1992; Repp & Karsh, 1994b; Emerson *et al.*, 1996). The study data were analysed on the basis of three second units in order to correspond with the level of interobserver agreement achieved. Agreement was calculated for multiple pairs of data files, given that the second observer conducted several observations of each participant. These results were aggregated across the files and an overall Kappa index was derived. Agreement measures were calculated on both the onset and occurrence of the target variable. These indicated whether observers agreed on the start and presence, respectively, of each observed variable. All event variables resulted in identical onset and occurrence measures due to the momentary nature of their duration.

The results of the interobserver agreement calculations are shown in sections 4.2.3.2 and 4.2.3.3 (in addition to Appendix F and Appendix H, as discussed below). Each Kappa

index is presented along with the operational definition of the corresponding behaviour. The index shown predominantly relates to the agreement attained for the particular behaviour in relation to the individual participant. However, in some cases the coefficients were aggregated across all participants. Aggregated indices were used under two circumstances only. Either the participant's behaviour was not exhibited while the second observer was in attendance or it occurred too infrequently for a level of agreement to be established. In respect of the first case, an asterisk was used to show that coefficients were aggregated across all the participants who engaged in that behaviour. In respect of the second case, both the aggregated coefficient and the low Kappa coefficient were presented.

4.2.3.2 *Operational Definitions of Participant Behaviours*

Challenging behaviours were conceptualised as being either a primary or secondary challenging behaviour type. The analyses were conducted separately on each type. Primary challenging behaviours were those considered traditionally in the literature as aggressive. These have included acts of aggression against other people, one's self and the environment. Secondary challenging behaviours were problematic behaviours that were less critical than the first type. The cessation of secondary challenging behaviours was a clinical goal, albeit a long term objective with low priority.

The operational definitions and agreement coefficients of primary challenging behaviours are presented in Table 4.8. A dash was used to indicate that the behaviour was not exhibited by the participant. The primary challenging behaviours that were recorded were *physical aggression*, *property destruction*, *self-injury* and *verbal aggression*. Three of these topographies were derived from more specific component behaviours. The *physical aggression* topography comprised *grabbing*, *hitting*, *kicking*, *pinching* or *punching*. The second composite topography was *self-injury*. This variable was formed from component self-injurious behaviours, such as *head banging*, *self-hitting* or *self-biting*. The *verbal aggression* topography was recorded according to severity, with four degrees ranging from a *mild outburst* to *extreme verbal aggression*. The only primary challenging behaviour topography not to be a composite variable was *property destruction*. This behaviour was coded at a single level. The manner in which environmental objects were damaged was not coded. The details of all the specific behaviour components that comprised each of the three composite topographies are provided in Appendix F. The operational definitions and the agreement coefficients for the constituent behaviours exhibited by each participant are also shown in Appendix F. A dash was used to indicate that the behaviour was not exhibited by the participant and hence was not a member of the composite primary challenging behaviour.

The operational definitions and agreement coefficients of secondary challenging behaviours are presented in Table 4.9. The information is presented by listing the behaviours exhibited by each participant. All participants, except for participant 3, engaged in at least one form of secondary challenging behaviour.

4.2.3.3 *Operational Definitions of Staff Behaviours*

The coding scheme for staff behaviours was fixed. The same responses were recorded consistently throughout all observations. Staff behaviours were categorised in terms of physical and verbal behaviours. As mentioned in section 4.2.2.1, some verbal staff behaviours were coded as event variables. These variables were then combined to create a duration variable, as described in 4.2.4.1. The operational definitions and agreement coefficients of staff behaviours are presented in Table 4.10. The agreement coefficients for these behaviours were calculated across all participants.

4.2.4 *Data Analysis*

4.2.4.1 *Data Preparation Prior to Analyses*

Some verbal staff behaviours were coded as event variables despite being durational in nature, as mentioned in 4.2.2.1. This was adopted for *demand*, *negative feedback* and *positive feedback*. All event variables that occurred within three seconds of each other were amalgamated as one durational variable. Variables occurring outside this burst were considered to represent separate instances.

To satisfy the inclusion criteria for analyses, the frequency of a variable had to be greater than nine or its duration had to exceed 0.1% of the total observation time. Exclusions on these grounds were necessary for statistically meaningful findings to have emerged from the analyses. The summary statistics of the primary and secondary challenging behaviours that were coded but excluded from the study are shown in Appendix G. As noted in the table, some specific components of *physical aggression* could have been incorporated within the composite physical aggression topography. However, they were excluded because no interobserver agreement measure was available. These behaviours were not witnessed at all by the second observer. With no possible verification of agreement, such behaviours were not included as a constituting part of the composite topography.

Table 4.8 Operational definitions and Kappa values of primary challenging behaviours

Behaviour	Operational Definition		Kappa Values for Each Participant (calculated on both presence and onset)								
			1	2	3	4	5	6	7	8	9
Physical aggression	An attempted or successful physical assault directed at another person, regardless of whether it may or may not cause an actual bodily injury	Presence	–	.72	.59	.48	–	.72	.63	.60	.63*
		Onset	–	.73	.39 / .59	.54	–	.67	.63	.33 / .59	.59*
Property destruction	A forceful act directed at an inanimate object, without necessarily breaking or marking it	Presence	–	1.0	.80	.77	.88	1.0	.71	–	–
		Onset	–	1.0	.80	.77	.78	1.0	.71	–	–
Self-injury	A successful self-directed physical assault, which may or may not cause actual bodily injury, using either one's person or an external object to inflict the force	Presence	–	–	.86	.84*	–	–	–	.53	–
		Onset	–	–	.79	.77*	–	–	–	.50	–
Verbal aggression	A vocal outburst (of words or noise) that is shouted, or any speech containing swearing, or an insult or threat directed at another person	Presence	.79	.80	.93	.50	.82	.71	.53	–	.28 / .72
		Onset	.79	1.0	.37 / .49	.50	.50	.59	.41	–	.33 / .49

Table 4.9 Operational definitions and Kappa values of secondary challenging behaviours

Participant	Behaviour	Operational Definition	Kappa	
			Presence	Onset
1	Sexually inappropriate	Touching the sexual parts of another person, making sexually suggestive comments, exposing oneself, masturbating or attempting to remove clothing	.73	.67
2	Flailing	Waving and swinging around of arms in an erratic manner, which is not necessarily directed at another person and may occur even when away from others	.76	.51
2	Pacing	Walking up and down repeatedly over a large or small confine	1.0	1.0
2	Teeth grinding	Gnashing and rubbing together of teeth which is accompanied with a grating sound	.95	.42
4	Requesting	Making verbal or gestural pleas to a member of staff for desired items, such as snacks, drinks or cigarettes	.71	.47
4	Sexually inappropriate	Touching the sexual parts of another person, making sexually suggestive comments, exposing oneself, masturbating or attempting to remove clothing	.99	.61
4	Touching	Touching staff members in a non-sanctioned manner, such as leaning on shoulders, holding neck or locking arms	.81	.41
5	Colliding	Bumping into another person or an object while pacing	.65	.65
5	Pacing	Walking up and down repeatedly over a large or small confine	.97	.40
5	Verbalising	Attempting to communicate with another person using indecipherable vocalisations	.81	.50
6	Perseverating	Repeatedly reciting a phrase, word or indecipherable verbalising with little or no pause between each recitation	.74	.68
7	Self-propelling	Repeatedly moving up and down over a large or small confine by propelling a wheel chair	.80	.33
7	Verbalising	Attempting to communicate with another person using indecipherable vocalisations	.64	.56
8	Sexually inappropriate	Touching the sexual parts of another person, making sexually suggestive comments, exposing oneself, masturbating or attempting to remove clothing	.63	.48
9	Requesting	Making verbal or gestural pleas to a member of staff for desired items, such as snacks, drinks or cigarettes	.65	.54
9	Sexually inappropriate	Touching the sexual parts of another person, making sexually suggestive comments, exposing oneself, masturbating or attempting to remove clothing	.87*	.52*

Table 4.10 Operational definitions and Kappa values of staff behaviours

Behaviour	Operational Definition	Kappa	
		Onset	Presence
Verbal Responses			
Demand	Offering a verbal or physical prompt to instruct the participant to act	.60	.68
Deny	Explicitly rejecting a request made by the participant for a desired item	.69	.69
Negative feedback	Giving non-affirmative verbal comments and/or removing tangible rewards, in a structured manner at a predetermined time	.62	.62
Positive feedback	Giving affirmative verbal comments and/or tangible rewards, in a structured manner at a predetermined time	.62	.62
Praise	Making a verbal comment, in an informal and unstructured manner, to commend the participant	.71	.71
Question	Asking a social, non-care related point	.64	.64
Reprimand	Making a verbal comment, in an informal and unstructured manner, to reproach the participant	.59	.59
Staff interaction	Engaging in social, non-care related conversation	.43	.84
Physical Responses			
Assist	Physically facilitating the participant to carry out an act	.55	.91
Restraint	Holding the extremities of the participant to contain their physical movement	.53	.95
Staff proximity	Being physically situated within one metre of the participant for more than three seconds	.44	.96

The staff identified sleeping and lying down as problem behaviours for some participants. These behaviours were recorded but not included in the study. In relation to those who exhibited these behaviours, sleeping and lying were removed from the analyses. The operational definitions and the agreement coefficients of these incidental behaviours are provided in Appendix H. The descriptive summaries of these variables are provided in Appendix I.

4.2.4.2 Analysis of Antecedents

A principal aim of the study was to investigate whether challenging behaviours were associated with environmental events. Correlational analyses were conducted to measure the likelihood of challenging behaviours and environmental events occurring concurrently. These analyses used the Yule's Q index to assess such associations (see, Hall *et al.*, 1997; Oliver, Hall, & Nixon, 1999). This measurement was a standardised version of the odds ratio. A comprehensive description of conditional probabilities and the rationale for using Yule's Q

are provided in Appendix J. The analyses concerned the probability of challenging behaviours and environmental events co-occurring in the same three-second time frame. Such concurrent analyses were applied separately to both the primary and secondary challenging behaviours.

A Yule's Q integer greater than or equal to .5 was taken to indicate a significant co-occurrence between the challenging behaviour and the environmental event. This represented a level of association three times greater than that expected by chance. A Yule's Q value greater than or equal to .8 corresponded to a level of association five times greater than that expected by chance. All significant associations were interpreted to ascertain the most probable antecedent to the behaviour. The presumed antecedent was ascribed by examining variations in significant results. Such interpretations were made using a fixed set of rules. These were based on the assumption that the environmental event preceded the challenging behaviour. It was a fair premise that the environmental event was the antecedent of the behaviour. Once the presumed antecedent for a challenging behaviour had been established, a possible function of the behaviour was determined also. It was probable that some challenging behaviours were ascribed multiple antecedents and functions.

The rules used to establish the most credible antecedent took the form of a flowchart. The algorithm is shown in Figure 4.1. A process from the start to the end of the flowchart was followed. The product of the algorithm was supplied by the grey rectangular boxes. The final result was determined by all the statements from each grey box that the process passed through. The algorithm deciphered the results of the concurrent analyses in terms of socially mediated reinforcement processes. The findings were conceptualised in terms of either positive social reinforcement, negative reinforcement in the form of demand escape or negative reinforcement in the form of social escape. A process of socially mediated positive reinforcement was in effect when the occurrence of the behaviour was suppressed under conditions of attention. The antecedent was presumed to be the absence of instructional or non-instructional contact. This was characterised by a significant negative association with demand and/or social contact. A negative reinforcement contingency in the form of demand escape was determined when the occurrence of the behaviour was most likely under demand conditions. The antecedent stimulus was presumed to be the presence of demand. This was characterised by a significant positive association with physical demands, verbal demands or both. A process of negative reinforcement in the form of social escape was ascertained when the behaviour showed a significant positive association with social attention only. In such cases the aversive stimulus preceding the behaviour was presumed to be the presence of non-instructional social contact.

Assertions about the presumed antecedents were made only when the challenging behaviour exhibited a significant association with at least one environmental event. Hence, no conclusion about the possible function of the behaviour was reached without significant associations. The algorithm was designed to discover the existence of multiple reinforcement processes. The outcome of the algorithm was not limited to a single process. The existence of several reinforcement contingencies operating simultaneously was decipherable. The algorithm ended in an error message if the results of a concurrent analysis were incongruent with the rule operations of the flowchart. In such cases the patterns of responding were interpreted manually by applying the overall principles of the algorithm as closely as possible. These special outcomes were highlighted with an asterisk next to the result.

Two mutually exclusive categories were devised to correspond to the relevant establishing operations of demand and attention. The environmental event *all demands* comprised two elements: *verbal demands* and *physical demands*. The environmental event *verbal demands* related to the staff behaviour demand that occurred in the absence of any *physical demands*. The environmental event *physical demands* related to the staff behaviour assist that occurred in the absence of any *verbal demands*. Given the expected overlap in the occurrence of *demand* and *assist*, it was necessary to filter out one from the other and establish an uncontaminated variable of *verbal demands* or *physical demands*. In this way it was possible to investigate the antecedent control of not only demand generally but also of specific aspects of demand. It was feasible to evaluate whether *verbal demands* and *physical demands* were functionally distinct or whether they shared the same aversive qualities.

The environmental event *social contact* was a combined variable which comprised all kinds of social attention that was not demand related. Thus, *social contact* was a combination of the following staff behaviours: *negative feedback*, *positive feedback*, *praise*, *question*, *reprimand*, *staff interaction*. As way of verification, a category that related to all forms of demand and social attention was created. This environmental event *all contact* was made up of *social contact* and *all demands*. This corroborative variable was necessary since instructional demands can be conceptualised additionally as a form of social attention. The environmental event *all contact* did not carry any such assumptions and provided a means of interpreting the results in terms of both establishing operations demand and attention.

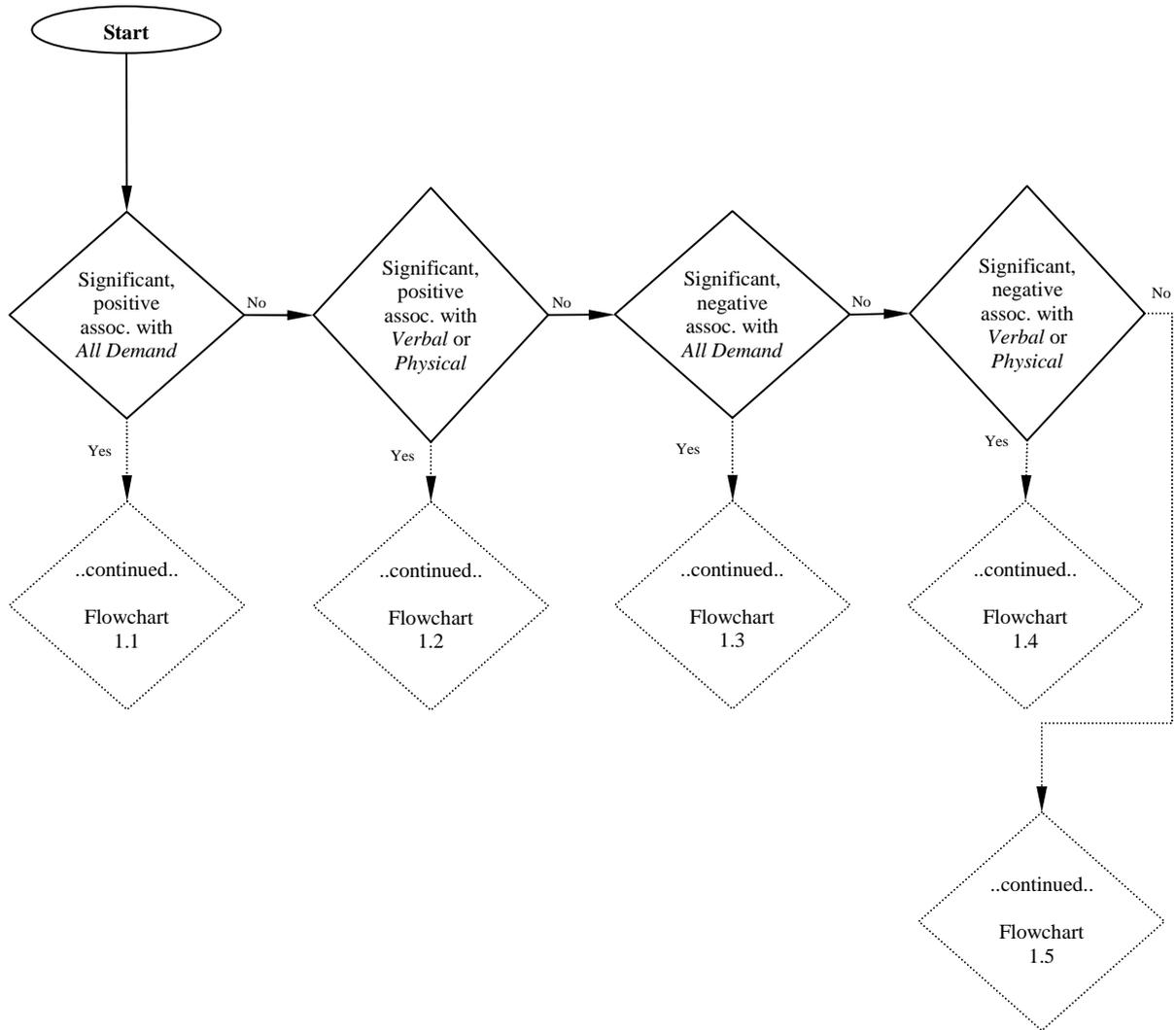


Figure 4.1 Algorithm for interpreting concurrent analysis results

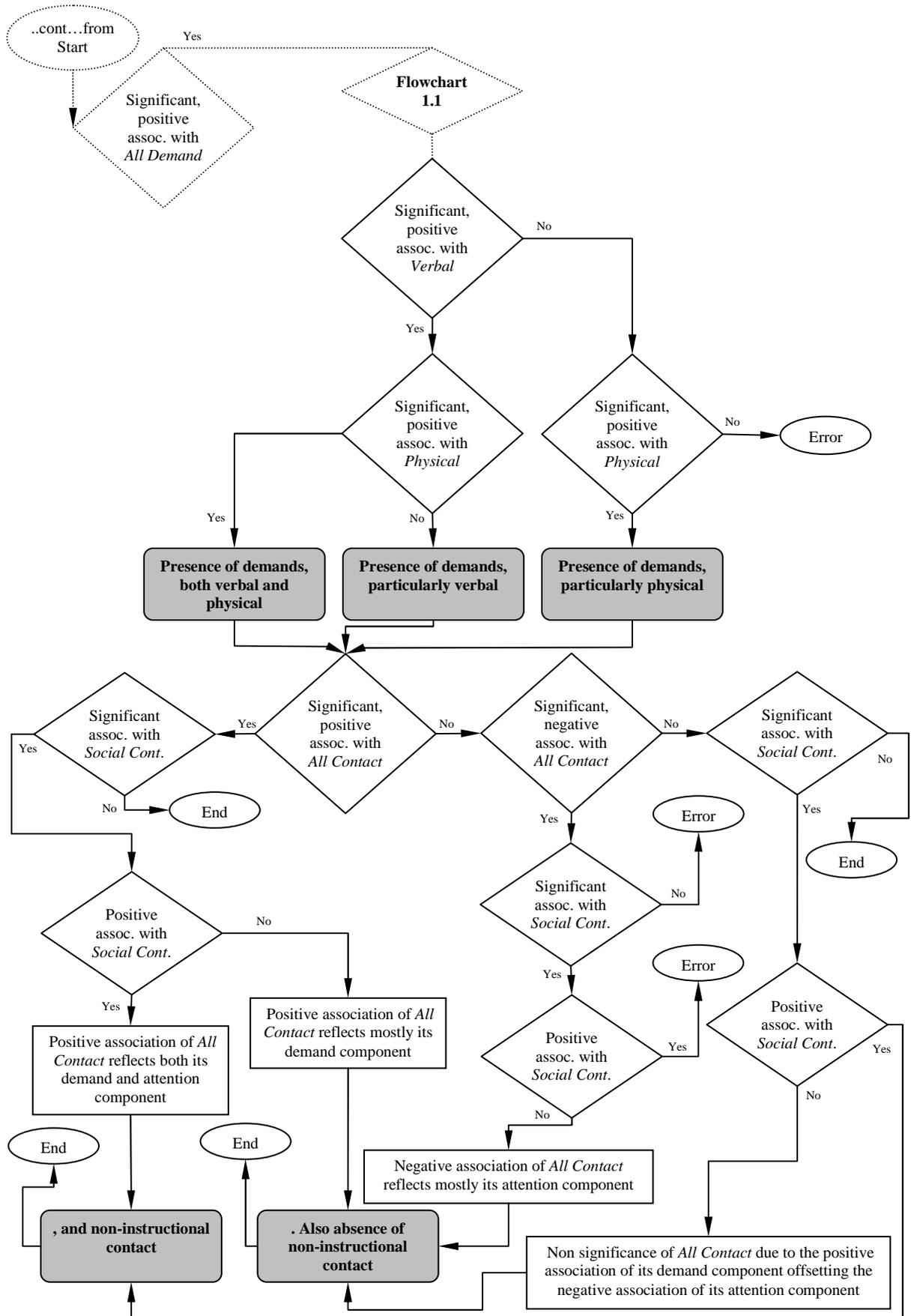


Figure 4.1 (cont.) Algorithm for interpreting concurrent analysis results

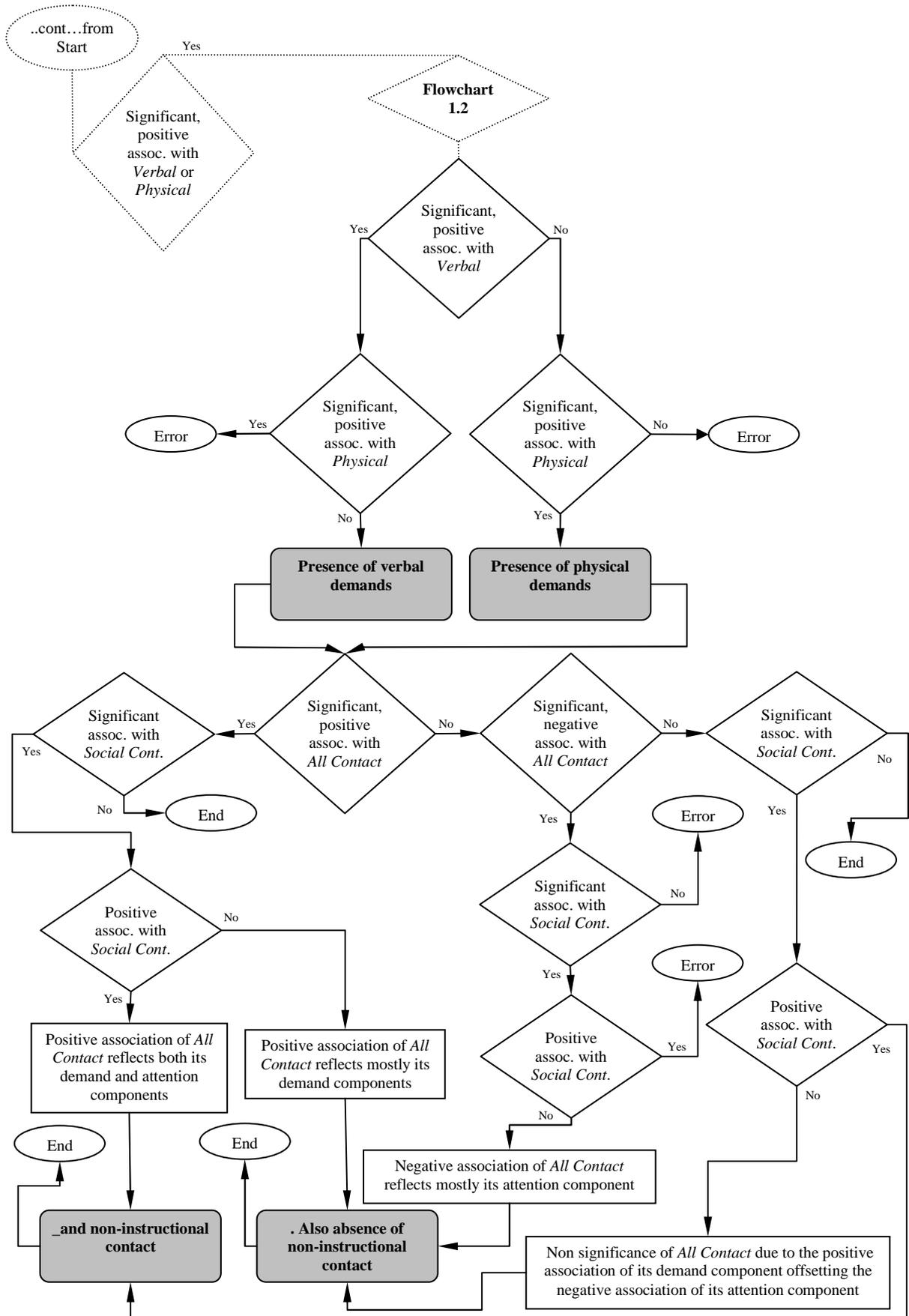


Figure 4.1 (cont.) Algorithm for interpreting concurrent analysis results

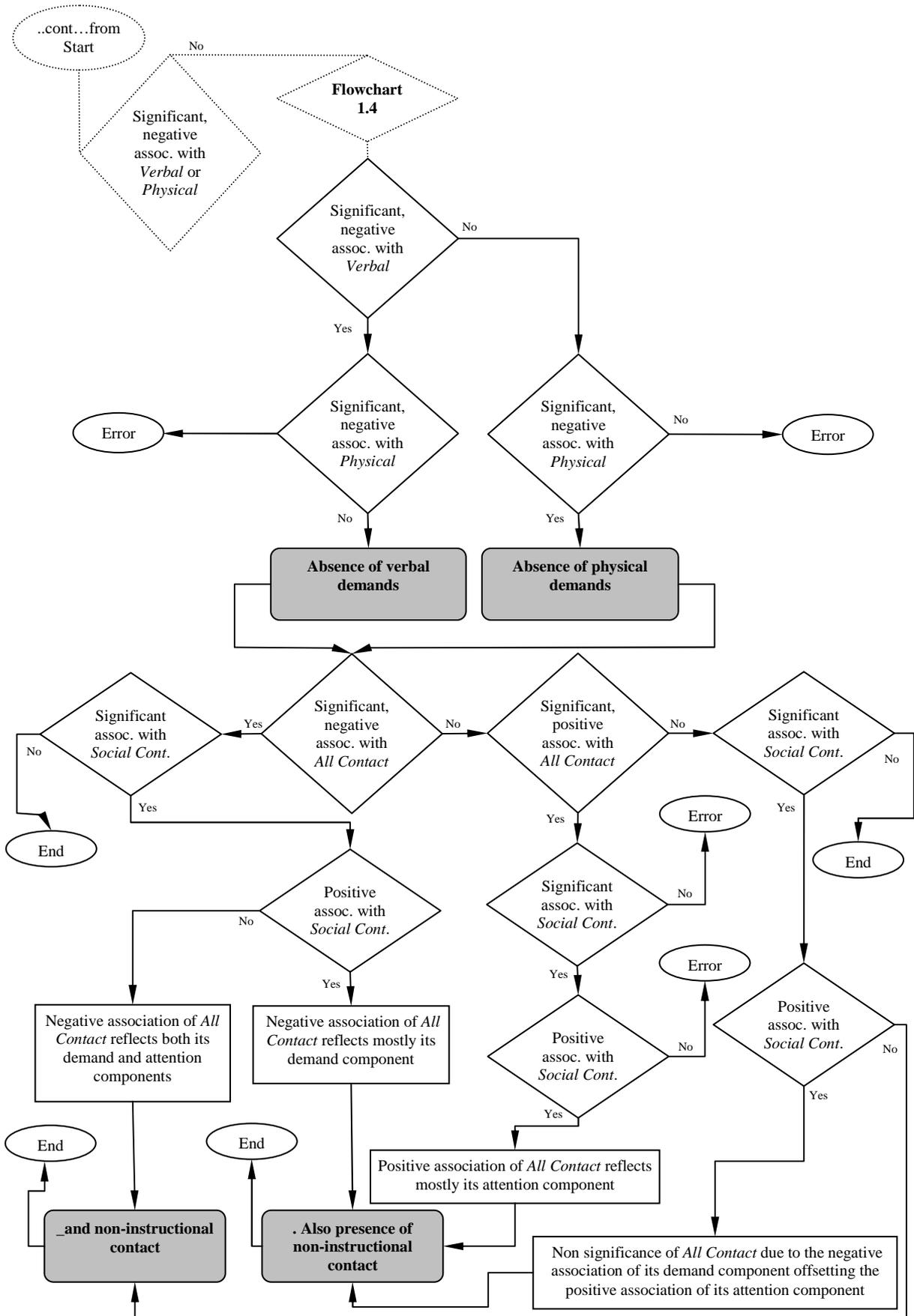


Figure 4.1 (cont.) Algorithm for interpreting concurrent analysis results

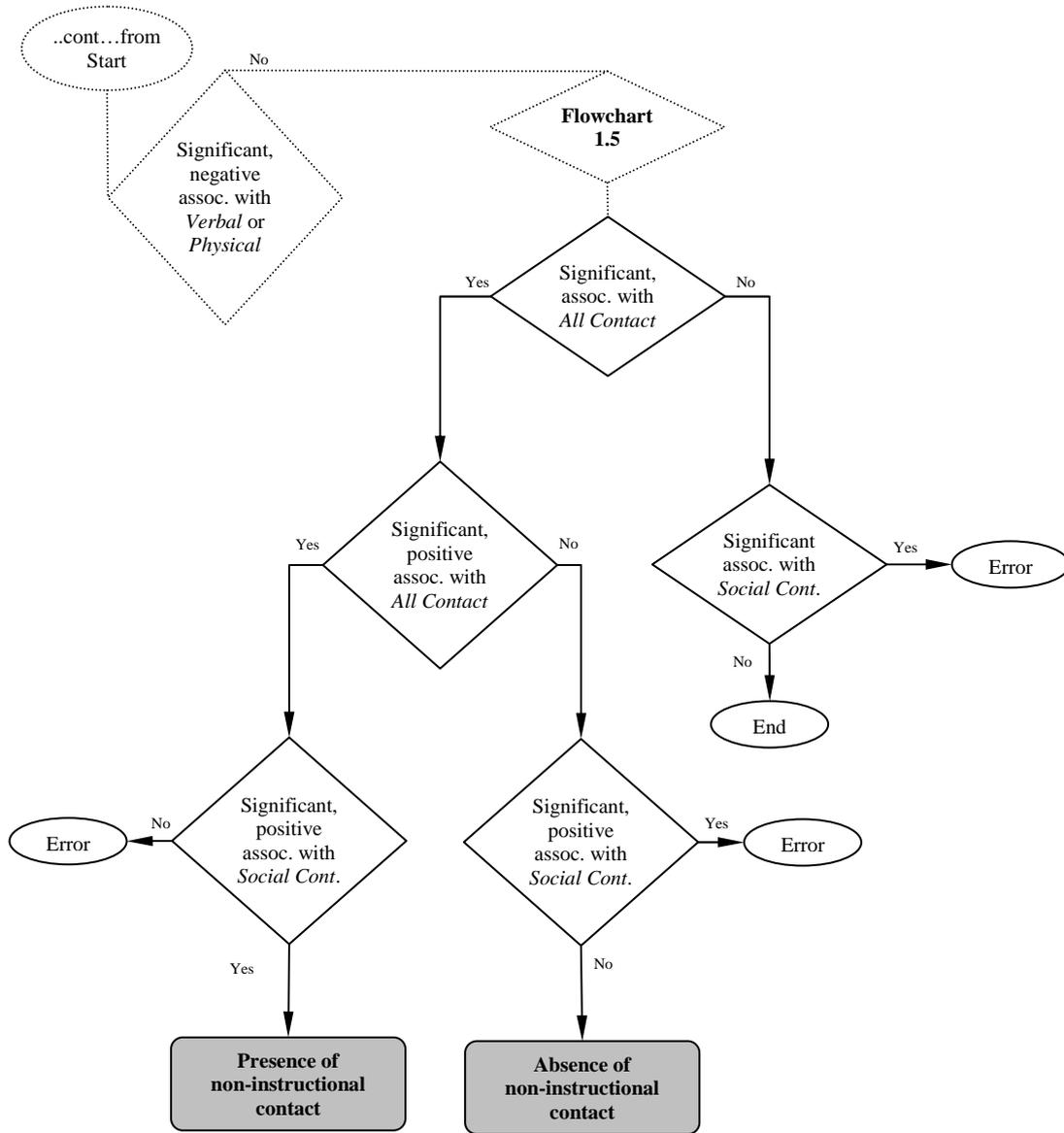


Figure 4.1 (cont.) Algorithm for interpreting concurrent analysis results

4.2.4.3 *Analysis of Reinforcement Contingencies*

The aim of the study was to evaluate associations between challenging behaviours and environmental events. However, these investigations were correlational and did not show causality. A significant co-occurrence between a challenging behaviour and an environmental event did not demonstrate that one variable exhibited control over the other. The assertions derived from concurrent analyses regarding the functions of challenging behaviours were tentative. Consequently, sequential analyses were conducted to corroborate these findings. Asserted functions were verified by the existence of consistent reinforcement processes. So the second aim of the study was to conduct sequential analyses to test whether patterns of responding corresponded to reinforcement contingencies. Sequential analyses assessed the temporal relationship between challenging behaviours and establishing operations, be it demand or attention. Then the distributive trends of the establishing operation relative to the challenging behaviour were examined.

The normalise-and-pool approach to sequential analysis was adopted (Hall & Oliver, 1997; 2000). This approach determined the conditional probabilities of environment events at each percentile interval before, during and after a challenging behaviour. The output was examined to ascertain whether the profile of responding corresponded to a process of mutual reinforcement. Specific patterns of responding were required to support a social reinforcement model. For instance, four features were expected in a profile consistent with a positive reinforcement contingency (see, Oliver, Hall & Murphy, 2005): (a) a diminishing likelihood of social contact leading up to the onset of the behaviour; (b) the likelihood of social contact to reach its lowest point directly before the onset of the behaviour; (c) an increasing likelihood of social contact following the onset of the behaviour; and, (d) a substantial increase in social contact following the behaviour compared to the period prior to the behaviour. For a behaviour that is negatively reinforced, by escape from demands, for instance, then the four expected profile features would be inverted: (a) an increasing likelihood of demands leading up to the onset of the behaviour; (b) the likelihood of demands to reach its highest point directly before the onset of the behaviour; (c) a decreasing likelihood of demands following the onset of the behaviour; and, (d) a substantial decrease in demands following the behaviour compared to the period prior to the behaviour.

The normalise-and-pool approach was defined by its facility to calculate the conditional probability of a dependent variable occurring at each percentile interval before, during and after an independent variable. This calculation of probabilities at all percentile intervals required the standardisation of periods of time. This was done by splitting the

number of time units between each pair of independent variables in half. The time units were those between the offset of an independent variable and the onset of the next. The first half of the time units was assigned as the consequence period of the first independent variable. The second half was allocated as the antecedent period of the second independent variable. The concurrent period related to the time units taken up in the duration of the independent variable. Each defined period then was normalised so that the occurrence of the dependent variable could be calculated at each percentile. The rate of occurrence of all dependent variables in each percentile was summed (Hall & Oliver, 2000). The approach therefore controlled for differences in the duration of the independent variable and accommodated all lengths of time between bursts of the independent variable.

The results of the sequential analyses are presented in sections 4.3.2.2 and 4.3.3.2. The normalise-and-pool technique was applied to all challenging behaviours that were significantly associated with an environmental event, i.e. those behaviours that were attributed function following the concurrent analysis. However, analyses were not conducted on low frequency behaviours. A sufficient number of variables were necessary for substantive findings to emerge. A minimum of twenty behavioural bursts was set as the criteria necessary for inclusion. The outcome of each sequential analysis was presented in a graph. The conditional probability of the establishing operation occurring at a particular point was represented on the y -axis. The range between the minimum and maximum values was shown on this axis. The percentiles of time units in the periods before, during and after the challenging behaviour were represented on the x -axis. Each period was demarked on the axis.

4.2.4.4 *Summary of Data Analyses*

The analysis topics and methods used that relate to the assessment of function are summarised in Table 4.11.

Table 4.11 Summary of data analyses

Assessment	Analysis	Method	Variables	IV	DV	Outcomes
Function of behaviours	Antecedents	Concurrent analysis	Primary CB	Environmental event	CB ¹	Co-occurrences of variable – function derived from significant findings ²
			Secondary CB			
	Reinforcing contingencies	Sequential analysis: Normalise-and-pool	Primary CB	CB ¹	Discriminative stimulus	Response patterns that corresponded to a social reinforcement model
			Secondary CB			

Abbreviations:

CB Challenging Behaviour

¹ Analysis conducted separately for primary and secondary challenging behaviour types² Significant findings of association interpreted using an algorithm to determine function

4.3 RESULTS

The results are covered in four sections. The summary statistics of both primary and secondary challenging behaviour types are described first. Then the outcomes of descriptive analyses of behavioural function are shown. Here the results of both concurrent and sequential functional analyses are introduced for each behaviour type separately.

4.3.1 *Descriptive Statistics*

The summary statistics for primary and secondary challenging behaviour types are covered in sections 4.3.1.1 and 4.3.1.2, respectively. The extent to which primary challenging behaviours occurred in each social setting activity is presented in section 4.3.1.3.

4.3.1.1 *Primary Challenging Behaviours*

All participants exhibited at least one primary challenging behaviour. All participants except one showed *verbal aggression*. *Physical aggression* and *property destruction* was demonstrated by seven participants. Three participants exhibited *self-injury*. One third of participants displayed all topographies of primary challenging behaviour. Summary statistics of the primary challenging behaviours are presented in Table 4.12.

Table 4.12 Primary challenging behaviours: Summary statistics

Participant	Primary Challenging Behaviour	Variable Type	Proportion of Total Time (%)	Median Duration (sec)	Frequency	
					Total	Per Hour
1	Verbal aggression	Duration	0.17	1	79	6.1
2	Physical aggression	Duration	0.09	1	49	2.8
2	Property destruction	Duration	0.05	1	30	1.7
2	Verbal aggression	Duration	0.19	4	21	1.2
3	Physical aggression	Duration	0.94	1	174	18.0
3	Property destruction	Event	0.14	1	52	5.4
3	Self-injury	Duration	3.15	2	292	30.2
3	Verbal aggression	Duration	16.17	11	273	28.2
4	Physical aggression	Duration	0.05	1	26	1.0
4	Property destruction	Duration	0.12	1	118	4.7
4	Self-injury	Duration	0.04	1	25	1.0
4	Verbal aggression	Duration	0.15	2	55	2.2
5	Property destruction	Duration	0.32	3	44	2.3
5	Verbal aggression	Duration	2.87	3	308	16.0
6	Physical aggression	Duration	0.16	1	85	3.5
6	Property destruction	Event	0.02	1	18	0.7
6	Verbal aggression	Duration	0.49	1	291	12.0
7	Physical aggression	Duration	0.29	1	146	7.4
7	Property destruction	Event	0.43	1	322	16.4
7	Verbal aggression	Duration	4.15	3	763	38.8
8	Physical aggression	Duration	0.10	1	28	1.8
8	Self-injury	Duration	0.14	1	39	2.6
9	Physical aggression	Duration	0.06	1	15	1.7
9	Verbal aggression	Duration	1.29	1	217	24.9

4.3.1.2 Secondary Challenging Behaviours

All except participant 3 exhibited at least one form of secondary challenging behaviour. Three participants presented with three forms. The most common was *sexually inappropriate* behaviour, which was shown by four participants. Summary statistics of the secondary challenging behaviours are presented in Table 4.13.

Table 4.13 Secondary challenging behaviours: Summary statistics

Participant	Secondary Challenging Behaviour	Variable Type	Proportion of Total Time (%)	Median Duration (sec)	Frequency	
					Total	Per Hour
1	Sexually inappropriate	Duration	.35	1	106	8.2
2	Flailing	Duration	2.64	6	147	8.4
2	Pacing	Duration	3.86	10	13	0.7
2	Teeth grinding	Duration	10.32	7	281	16.0
4	Requesting	Duration	1.35	3	288	11.4
4	Sexually inappropriate	Duration	6.76	6	102	3.9
4	Touching	Duration	2.85	4	309	12.2
5	Colliding	Event	0.16	1	111	5.8
5	Pacing	Duration	21.99	63	108	5.6
5	Verbalising	Duration	8.60	3	1304	67.9
6	Perseverating	Duration	2.04	2	900	37.1
7	Self-propelling	Duration	16.25	15	484	24.6
7	Verbalising	Duration	12.23	2	3045	154.7
8	Sexually inappropriate	Duration	3.36	1	786	51.5
9	Requesting	Duration	1.91	1	469	53.7
9	Sexually inappropriate	Duration	0.48	1	95	10.9

4.3.1.3 Social Setting Activities

The extent to which challenging behaviours occurred in each social setting activity is presented in Figure 4.2. The calculations were conducted across all participants. The proportion of each social setting activity in which challenging behaviours occurred is shown in the bar chart and data table. The distribution is depicted in terms of individual topographies also.

Challenging behaviours occurred for nearly a third of seclusion time (29.07%). Thereafter, the social setting activities with the highest proportion of challenging behaviours were the hygiene programme (7.9%) and intervention (5.9%). Challenging behaviours were least likely to occur during mealtimes and group activities. Verbal aggression was the most likely topography to be exhibited across all social setting activities.

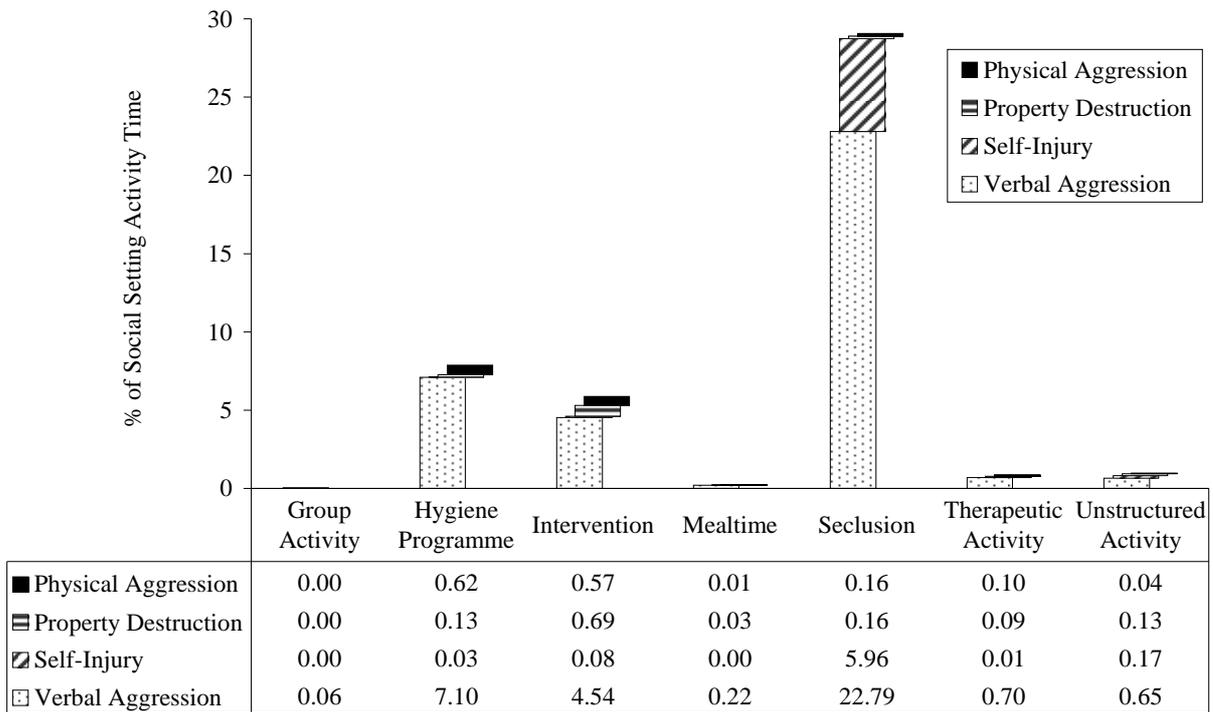


Figure 4.2 Bar chart and data table of the extent to which challenging behaviour topographies occurred in each social setting activity

4.3.2 Function of Primary Challenging Behaviours

First, the results of concurrent analyses are presented. These are followed by the sequential analyses results. This section ends with a summary of the functions of primary challenging behaviours.

4.3.2.1 Concurrent Analysis

Across all participants, 21 primary challenging behaviours showed a significant association of co-occurrence with an environmental event. The algorithm was applied successfully to interpret these significant associations in all cases except for *physical aggression* by participant 9. No significant relationship with environmental events was found for three behaviours; *property destruction* by participant 2, *property destruction* by participant 4 and *verbal aggression* by participant 9.

The complete behavioural repertoire of some participants served the same function. For participants 3, 6 and 8, all the topographies exhibited were preceded by the same antecedents and were identical in terms of function. All the behaviours of each of these participants were functionally homogeneous. All four behaviours exhibited by participant 3 were maintained by a process of positive reinforcement mediated by all forms of staff attention. Each behaviour was significantly associated with the absence of *all demands*, both

verbal and physical, and the absence of *social contact*. Significant negative associations were recorded between *all demands* and *physical aggression* (Yule's $Q = -.76$), *property destruction* (Yule's $Q = -.68$), *self-injury* (Yule's $Q = -.90$) and *verbal aggression* (Yule's $Q = -.92$). The associations between these behaviours and social contact were also significant and negative (Yule's Q range $-.94$ to $-.99$). A comparable finding emerged for participant 6. All three behaviours exhibited by participant 6 served a demand escape function. *All demands*, both verbal and physical, were considered to precede the behaviours. Significant positive associations emerged between the behaviours and all kinds of instructional contact. In relation to *all demands* a significant positive association was found for *physical aggression* (Yule's $Q = .88$), *property destruction* (Yule's $Q = .68$) and *verbal aggression* (Yule's $Q = .74$). The behaviours presented by participant 8 also showed uniformity of function, albeit with less consistency. Both behaviours exhibited by participant 8 were governed by a socially mediated positive reinforcement process. The behaviours were contingent upon the absence of demands. Significant negative associations were found between *verbal demands* and *physical aggression* (Yule's $Q = -.77$) and between *all demands* and *self-injury* (Yule's $Q = -.88$). Additionally, *self-injury* was significantly associated with the absence of non-instructional social contact (Yule's $Q = -.76$).

There were other instances of multiple challenging behaviours that shared the same antecedents and served the same function. These challenging behaviours did not represent the complete behaviour repertoire. Some of the behaviours presented individually by participants 2, 4, 5 and 7 were functionally identical. These behaviours were ascribed a demand escape function. They demonstrated a significant positive association with demand intensive settings and, for some, a significant negative association with non-instructional environmental settings. For participant 2, *physical aggression* and *verbal aggression* both displayed a significant positive association with *verbal demands* (Yule's $Q = .90 / .78$, respectively). *Physical aggression* also co-occurred with *physical demands* (Yule's $Q = .79$). For participant 4, significant associations were recorded between *verbal demands* and both *physical aggression* (Yule's $Q = .68$) and *self-injury* (Yule's $Q = .59$). The *property destruction* and *verbal aggression* displayed by participant 5 were found to occur with *all demands* (Yule's $Q = .75 / .73$, respectively). For participant 7, *physical aggression* and *verbal aggression* occurred in the presence of *all demands*, particularly *physical demands*. The behaviours were identical in terms of their demand escape function. Significant positive associations existed between *all demands* and both *physical aggression* (Yule's $Q = .64$) and *verbal aggression* (Yule's $Q = .67$). In addition to those serving a demand escape function, participant 4 and 7 also exhibited behaviours that were maintained by a process of socially mediated positive

reinforcement. These were unlikely to occur in settings that involved staff contact. There was a significant negative association between these behaviours and non-instructional social contact and, for some, instructional contact also. For participant 4, *self-injury* and *verbal aggression* demonstrated a significant negative association with *social contact* (Yule's $Q = -.86 / -.91$, respectively). For participant 7, *social contact* was shown to be negatively associated with both *property destruction* (Yule's $Q = -.65$) and *verbal aggression* (Yule's $Q = -.65$).

Five behaviours were maintained by distinct reinforcement processes. These behaviours served multiple functions. Each was attributed with both a demand escape function and an attention seeking function. For participant 2, *verbal aggression* occurred during both *verbal demands* and in the absence of staff contact. *Verbal aggression* was positively associated with *verbal demands* (Yule's $Q = .78$) and also negatively associated with *social contact* (Yule's $Q = -.73$). The *self-injury* exhibited by participant 4 was assigned with the same twin functions. *Self-injury* was positively associated with *verbal demands* (Yule's $Q = .59$) and also negatively associated with *social contact* (Yule's $Q = -.86$). The *verbal aggression* exhibited by both participant 5 and 7 was attributed the same dual functions. *Verbal aggression* was positively associated with *all demands* (Yule's $Q = .73 / .67$, respectively) and negatively associated with *social contact* (Yule's $Q = -.57 / -.65$, respectively). For participant 9, *physical aggression* was positively associated with *verbal demands* (Yule's $Q = .60$) and negatively associated with *social contact* (Yule's $Q = -.73$).

Table 4.14 Associations between primary challenging behaviours and environmental settings

Participant	Primary Challenging Behaviour	E ^o - Demands			E ^o - Attention		Presumed Antecedent	Possible Function
		All Demands	Verbal Demands	Physical Demands	All Contact	Social Contact		
1	Verbal aggression	.65	.29	.65	.65	.26	Presence of demands, particularly physical	Dem-Esc
2	Physical aggression	.82	.90	.79	.79	-.49	Presence of demands, both verbal and physical	Dem-Esc
2	Property destruction	-.10	.44	-.09	-.18	-.49	-	-
2	Verbal aggression	.08	.78	.04	.01	-.73	Presence of verbal demands. Also absence of non-instructional contact	Dem-Esc, Soc-A
3	Physical aggression	-.76	-.77	-.74	-.85	-.99	Absence of demands, both verbal and physical, and non-instructional contact	Soc-A
3	Property destruction	-.68	.16	-.72	-.79	-.94	Absence of demands, particularly physical, and non-instructional contact	Soc-A
3	Self-injury	-.90	-.95	-.89	-.94	-.99	Absence of demands, both verbal and physical, and non-instructional contact	Soc-A
3	Verbal aggression	-.92	-.93	-.92	-.96	-.99	Absence of demands, both verbal and physical, and non-instructional contact	Soc-A

Abbreviations: Dem-Esc = Escape from instructional demands; Soc-Esc = Escape from social attention; Soc-A = Gain social attention

Note: * finding derived by applying the overall principles of the algorithm as closely as possible because the data did not conform exactly to the rules of the algorithm

Table 4.14 (cont.) Associations between primary challenging behaviours and environmental settings

Participant	Primary Challenging Behaviour	E ^o - Demands			E ^o - Attention		Presumed Antecedent	Possible Function
		All Demands	Verbal Demands	Physical Demands	All Contact	Social Contact		
4	Physical aggression	.55	.68	-.19	-.25	-.48	Presence of demands, particularly verbal	Dem-Esc
4	Property destruction	-.02	.09	-.27	-.34	-.40	–	–
4	Self-injury	.43	.59	-.06	-.50	-.86	Presence of verbal demands. Also absence of non-instructional contact	Dem-Esc, Soc-A
4	Verbal aggression	.10	-.23	.42	-.73	-.91	Absence of non-instructional contact	Soc-A
5	Property destruction	.75	.34	.75	.63	.02	Presence of demands, particularly physical	Dem-Esc
5	Verbal aggression	.73	.55	.71	.53	-.57	Presence of demands, both verbal and physical. Also absence of non-instructional contact	Dem-Esc, Soc-A
6	Physical aggression	.88	.51	.86	.86	-.40	Presence of demands, both verbal and physical	Dem-Esc
6	Property destruction	.68	.75	.62	.65	.36	Presence of demands, both verbal and physical	Dem-Esc
6	Verbal aggression	.74	.72	.70	.74	.27	Presence of demands, both verbal and physical	Dem-Esc

Abbreviations: Dem-Esc = Escape from instructional demands; Soc-Esc = Escape from social attention; Soc-A = Gain social attention

Note: * finding derived by applying the overall principles of the algorithm as closely as possible because the data did not conform exactly to the rules of the algorithm

Table 4.14 (cont.) Associations between primary challenging behaviours and environmental settings

Participant	Primary Challenging Behaviour	E ^o - Demands			E ^o - Attention		Presumed Antecedent	Possible Function
		All Demands	Verbal Demands	Physical Demands	All Contact	Social Contact		
7	Physical aggression	.64	.19	.69	.38	-.14	Presence of demands, particularly physical	Dem-Esc
7	Property destruction	-.41	-.01	-.59	-.58	-.65	Absence of physical demands and non-instructional contact	Soc-A
7	Verbal aggression	.67	.10	.73	.22	-.65	Presence of demands, particularly physical. Also absence of non-instructional contact	Dem-Esc, Soc-A
8	Physical aggression	.28	-.77	.37	.32	.35	Absence of verbal demands	Soc-A
8	Self-injury	-.88	-.83	-.86	-.87	-.76	Absence of demands, both verbal and physical, and non-instructional contact	Soc-A
9	Physical aggression	-.20	.60	-.66	-.52	-.73	Presence of verbal demand. Also absence of physical demands and non-instructional social contact *	Dem-Esc, Soc-A
9	Verbal aggression	.11	.49	-.12	.11	.10	-	-

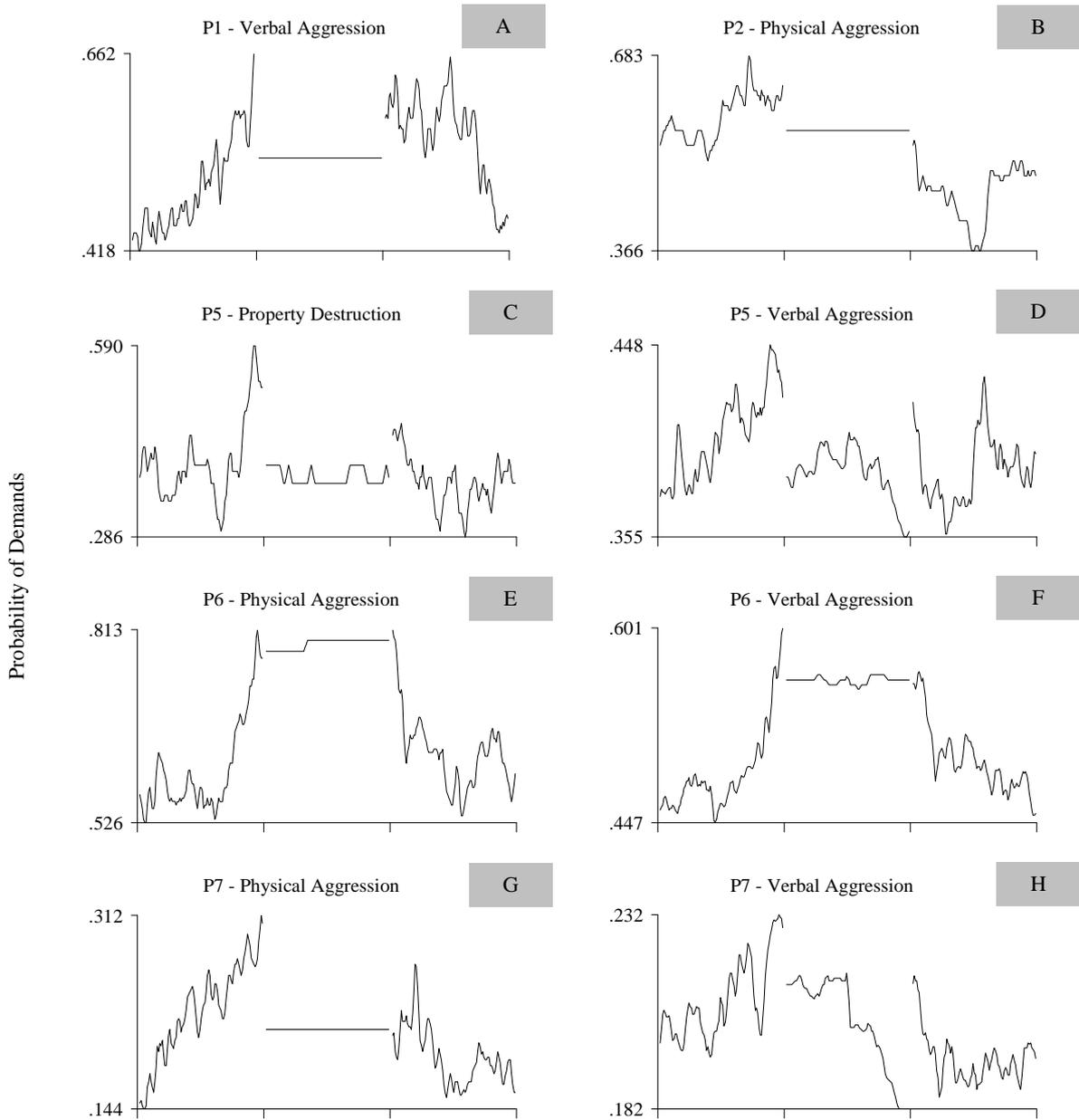
Abbreviations: Dem-Esc = Escape from instructional demands; Soc-Esc = Escape from social attention; Soc-A = Gain social attention

Note: * finding derived by applying the overall principles of the algorithm as closely as possible because the data did not conform exactly to the rules of the algorithm

4.3.2.2 *Sequential Analysis*

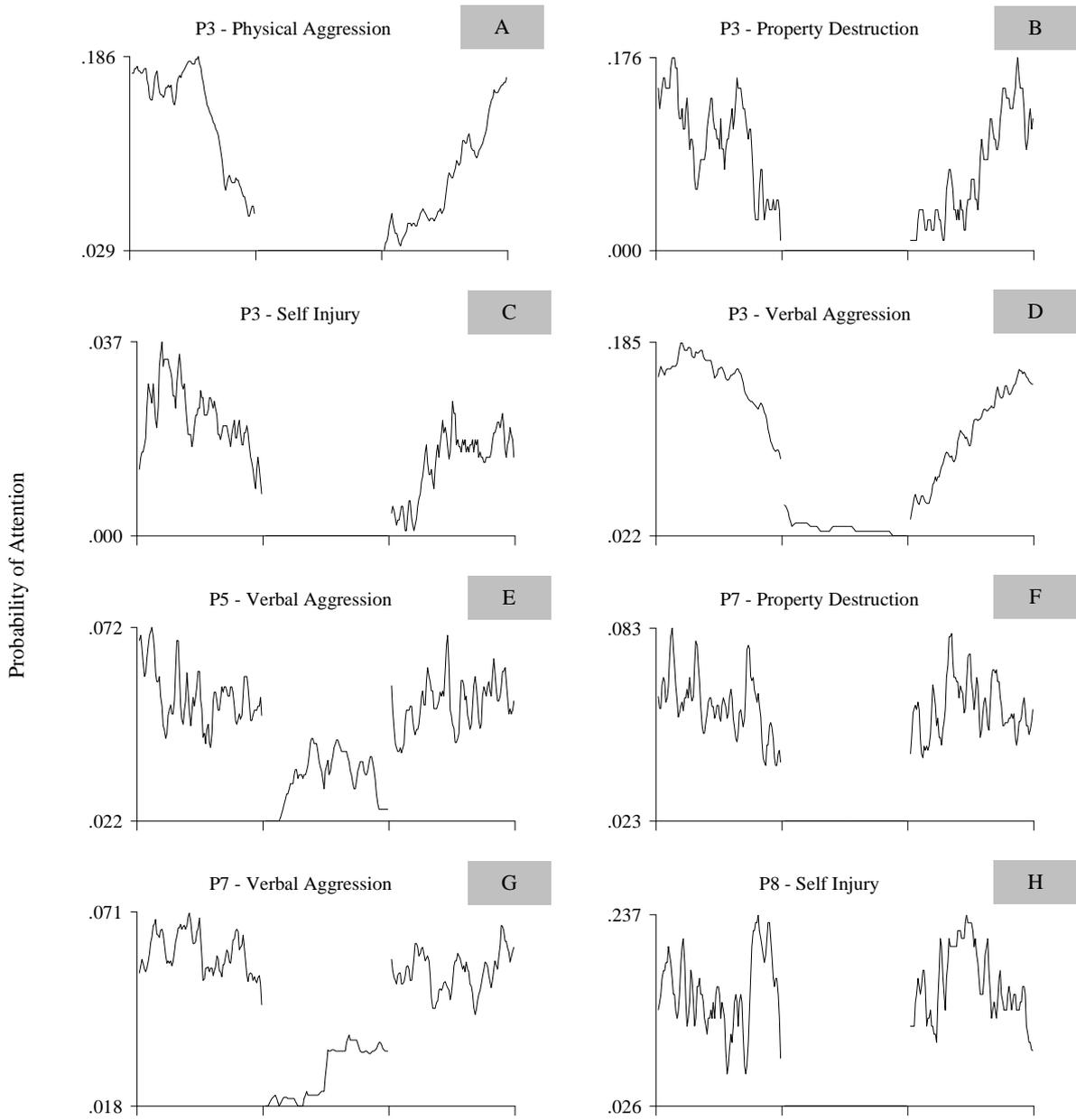
Across all participants, thirteen primary challenging behaviours were attributed a demand escape function following the concurrent analysis. Five of these behaviours did not meet the criteria for analysis, which necessitated a minimum of twenty behavioural bursts. The excluded behaviours were: *verbal aggression* by participant 2, *physical aggression* by participant 4, *self-injury* by participant 4, *property destruction* by participant 6 and *physical aggression* by participant 9. The remaining eight behaviours were suitable for further investigation. The summary plots of these analysed behaviours are shown in Figure 4.3. The plots are labelled using the letters A to H. All eight behaviours showed an increasing level of demand prior to their onset. For all eight behaviours the highest probability of demand in the antecedent period occurred directly prior to their onset. For two behaviours (D, H) there was a decreasing level of demand following their onset. For three behaviours (B, G, H) there was a substantial overall decrease in demand during the period following their offset compared to the period before their onset. In summary, one behaviour (H) demonstrated a profile consistent with all four features of a negative social reinforcement process, three behaviours (B, D, G) demonstrated three features and four behaviours (A, C, E, F) demonstrated two features.

Following the concurrent analysis, across all participants, thirteen primary challenging behaviours were attributed an attention maintained function. Five of these behaviours did not occur frequently enough to be included in the study. These were: *verbal aggression* by participant 2, *self-injury* by participant 4, *verbal aggression* by participant 4, *physical aggression* by participant 8 and *physical aggression* by participant 9. The summary plots for the eight behaviours that satisfied the inclusion criteria are shown in Figure 4.4. The plots are labelled using the letters A to H. Seven behaviours (A, B, C, D, E, F, G) showed a decreasing level of attention prior to their onset. For six behaviours (A, B, C, D, F, G) the lowest probability of attention in the antecedent period occurred directly prior to their onset. One behaviour (G) exhibited a pattern of increasing attention level following onset. None of the behaviours exhibited a substantial overall increase in attention following their offset compared to the period before their onset. In summary, one behaviour (G) demonstrated a profile consistent with three features of positive social reinforcement, five behaviours (A, B, C, D, F) demonstrated a profile consistent with two features and two behaviours (E, H) demonstrated one or zero features.



Percentiles of Time Units Before, During and After the Challenging Behaviour

Figure 4.3 Probability of staff demand occurring at each percentile in the periods before, during and after primary challenging behaviours



Percentiles of Time Units Before, During and After the Challenging Behaviour

Figure 4.4 Probability of staff attention occurring at each percentile in the periods before, during and after primary challenging behaviours

4.3.2.3 Summary

The results from the concurrent and sequential analyses are summarised in Table 4.15. Across all participants, three primary challenging behaviours had no significant association with an environmental event. The other 21 behaviours were attributed with a function using the method of concurrent analysis. The complete behavioural repertoire of three participants served the same function. Social attention maintained all the behaviours exhibited by participants 3 and 8. All the behaviours maintained by participant 6 served a demand escape function. Other pairs of behaviours also were attributed with identical functions. Five participants each presented a behaviour with multiple functions, which was reinforced by both positive and negative reinforcement processes. The findings derived from the concurrent analyses were confirmed when two or more features of a reinforcement process were demonstrated by sequential analyses. Only two findings, derived from the concurrent analysis, were actually contradicted by the results of the sequential analysis. Ten findings were not substantiated due to an insufficient number for analysis. Overall, 54% of concurrent analyses results ($n = 14/26$) were corroborated by the results of the sequential analyses. The results of both methods differed only 8% of the time ($n = 2/26$). A comparison of methods was not possible in 38% of cases ($n = 10/26$). If these instances were disregarded, across all evaluated findings, the concordance rate between concurrent and sequential analysis methods was 88% ($n = 14/16$).

Figure 4.15 Function of primary challenging behaviours derived from concurrent and sequential analyses

		Participants and their Exhibited Primary Challenging Behaviours																							
Function	Analysis Method	1	2			3				4				5		6			7			8		9	
		VA	PA	PD	VA	PA	PD	SI	VA	PA	PD	SI	VA	PD	VA	PA	PD	VA	PA	PD	VA	PA	SI	PA	VA
Social	Concurrent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Escape	Sequential	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Social	Concurrent	0	0	0	+	+	+	+	+	0	0	+	+	0	+	0	0	0	0	+	+	+	+	+	0
Attention	Sequential	n.a.	n.a.	n.a.	i.d.	+	+	+	+	n.a.	n.a.	i.d.	i.d.	n.a.	-	n.a.	n.a.	n.a.	n.a.	+	+	i.d.	-	i.d.	n.a.
Demand	Concurrent	+	+	0	+	0	0	0	0	+	0	+	0	+	+	+	+	+	+	0	+	0	0	+	0
Escape	Sequential	+	+	n.a.	i.d.	n.a.	n.a.	n.a.	n.a.	i.d.	n.a.	i.d.	n.a.	+	+	+	i.d.	+	+	n.a.	+	n.a.	n.a.	i.d.	n.a.

Key:

- 0 Function not apparent
- + Function revealed
- Function not confirmed by sequential analysis
- i.d. Insufficient data to conduct sequential analysis
- n.a. Sequential analysis not conducted as function not apparent

Abbreviations:

- PA Physical aggression
- PD Property destruction
- SI Self-injury
- VA Verbal aggression

4.3.3 *Function of Secondary Challenging Behaviours*

First, the results of concurrent analyses for secondary challenging behaviours are presented. These are followed by the results of the sequential analyses. This section ends with a summary of the functions of secondary challenging behaviours.

4.3.3.1 *Concurrent Analysis*

Across all participants, sixteen secondary challenging behaviours showed a significant association of co-occurrence with an environmental event. The algorithm was applied successfully to interpret these significant associations in all cases except for *requesting* by participant 4. No significant relationship was found for one topography exhibited by three participants; *sexually inappropriate* behaviour by participants 1, 8 and 9.

Some of the secondary challenging behaviours exhibited by three participants shared the same antecedents and served the same function. Two behaviours presented by participant 2 were ascribed the same demand escape function. They showed a significant positive association with demand intensive environmental settings. Both *flailing* and *teeth grinding* shared a significant positive association with *verbal demands* (Yule's $Q = .84 / .77$, respectively). *Flailing* also co-occurred with *physical demands* (Yule's $Q = .69$). In other cases the functionally homogenous behaviours were maintained instead by social attention. These behaviours were positively reinforced by attention and were unlikely to occur in settings that involved staff contact. They were significantly associated with the absence of social contact and, in some cases, instructional contact. For participant 2, *pacing* and *teeth grinding* demonstrated a significant negative association with *social contact* (Yule's $Q = -.54, -.52$, respectively). Additionally, *pacing* was negatively associated with other forms of instructional contact, including *all demands* (Yule's $Q = -.94$). For participant 4, significant associations were recorded between *all contact* and *sexually inappropriate* behaviour (Yule's $Q = -.55$) and also between *physical demands* and *requesting* (Yule's $Q = -.93$). For participant 5, *pacing* had a negative association with both *all contact* and *all demands* (Yule's $Q = -.56 / -.90$, respectively) and *colliding* was related to the absence of *verbal demands* (Yule's $Q = -.83$).

Some behaviours were ascribed a function that was not matched by any other within the participant's behavioural repertoire. The only behaviour exhibited by participants 7 and 9 to be maintained by social attention was *self-propelling* and *requesting*, respectively. The only behaviour negatively reinforced by demand escape was *touching* for participant 4, *verbalising* for participant 5 and *perseverating* for participant 6. The function of social escape was allocated in one instance. The *verbalising* presented by participant 7 was positively associated

with *social contact* (Yule's $Q = .84$). The behaviour was thought to be maintained by a process of negative reinforcement in the form of social escape.

The only example of a behaviour being maintained by different reinforcement processes was demonstrated by participant 2. *Teeth grinding* occurred during demands and in the absence of non-instructional contact. The behaviour was positively associated with *verbal demand* (Yule's $Q = .77$) and negatively associated with *social contact* (Yule's $Q = -.52$). As such, a dual function of demand escape and seeking attention was attributed to *teeth grinding*.

Table 4.16 Associations between secondary challenging behaviours and environmental setting

Participant	Secondary Behaviour	E ^o - Demands			E ^o - Attention		Presumed Antecedent	Possible Function
		All Demands	Verbal Demands	Physical Demands	All Contact	Social Contact		
1	Sexually inappropriate	.00	-.47	.13	.10	.32	–	–
2	Flailing	.71	.84	.69	.67	-.29	Presence of demands, both verbal and physical	Dem-Esc
2	Pacing	-.94	-.32	-.96	-.88	-.54	Absence of demands, particularly physical, and non-instructional contact	Soc-A
2	Teeth grinding	.35	.77	.32	.27	-.52	Presence of verbal demands. Also absence of non-instructional contact	Dem-Esc, Soc-A
4	Requesting	.22	.43	-.93	-.03	-.09	Absence of physical demands *	Soc-A
4	Sexually inappropriate	.12	.01	.26	-.55	-.69	Absence of non-instructional contact	Soc-A
4	Touching	.44	.54	.14	.53	.52	Presence of demands and non-instructional contact	Dem-Esc
5	Colliding	-.44	-.83	-.34	-.48	-.49	Absence of verbal demands	Soc-A

Abbreviations: Dem-Esc = Escape from instructional demands; Soc-Esc = Escape from social attention; Soc-A = Gain social attention

Note: * finding derived by applying the overall principles of the algorithm as closely as possible because the data did not conform exactly to the rules of the algorithm

Table 4.16 (cont.) Associations between secondary challenging behaviours and environmental setting

Participant	Secondary Behaviour	E ^o - Demands			E ^o - Attention		Presumed Antecedent	Possible Function
		All Demands	Verbal Demands	Physical Demands	All Contact	Social Contact		
5	Pacing	-.90	-.83	-.91	-.56	-.16	Absence of demands, both verbal and physical	Soc-A
5	Verbalising	.66	.59	.65	.58	.24	Presence of demands, both verbal and physical	Dem-Esc
6	Perseverating	.62	.23	.64	.59	-.03	Presence of demands, particularly physical	Dem-Esc
7	Self-propelling	-.86	-.46	-1.0	-.69	-.58	Absence of demands, particularly physical, and non-instructional contact	Soc-A
7	Verbalising	-.19	.42	-.43	.76	.84	Presence of non-instructional contact	Soc-Esc
8	Sexually inappropriate	.36	-.12	.41	.30	-.35	-	-
9	Requesting	-.10	-.73	.00	-.56	-.72	Absence of verbal demand, and non-instructional contact	Soc-A
9	Sexually inappropriate	.07	.20	-.19	-.03	.05	-	-

Abbreviations: Dem-Esc = Escape from instructional demands; Soc-Esc = Escape from social attention; Soc-A = Gain social attention

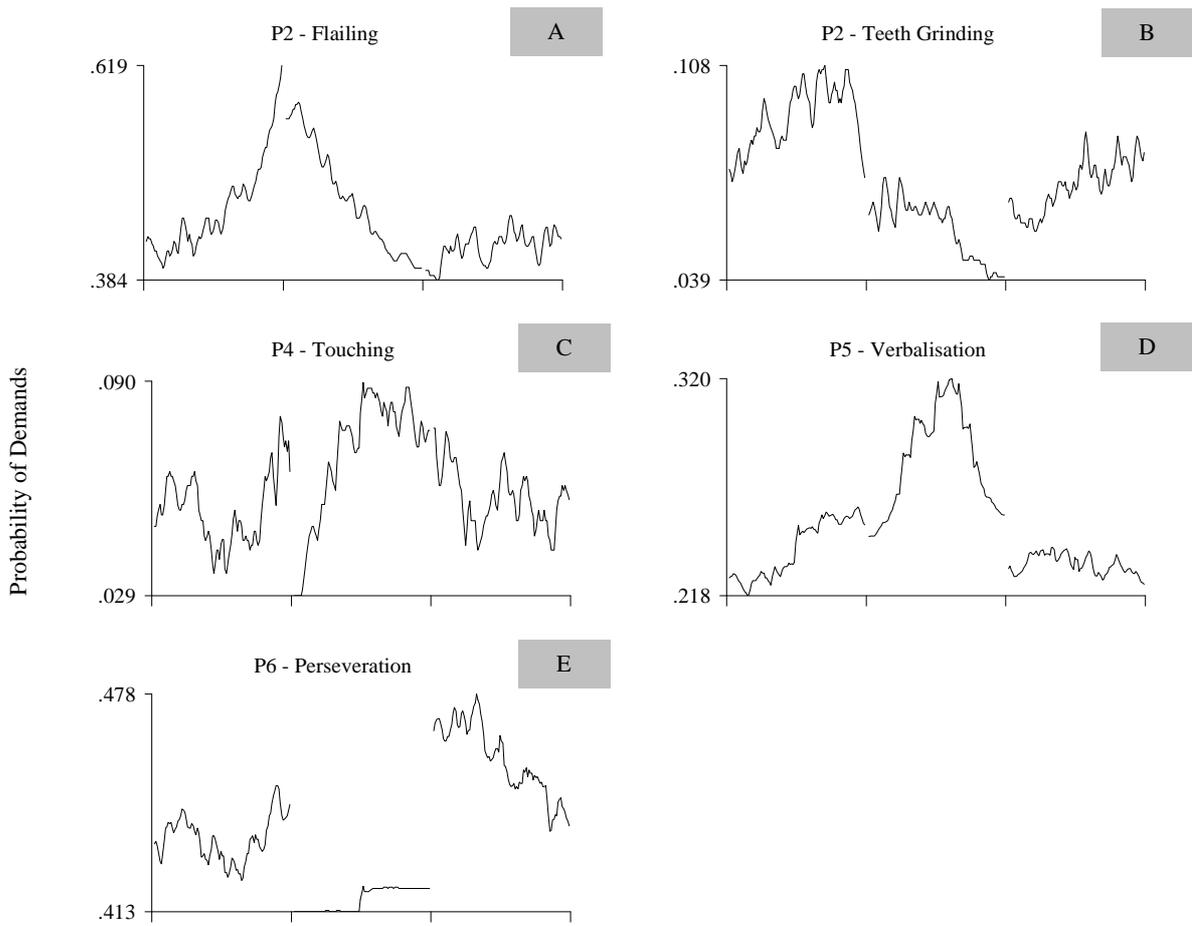
Note: * finding derived by applying the overall principles of the algorithm as closely as possible because the data did not conform exactly to the rules of the algorithm

4.3.3.2 *Sequential Analysis*

Across all participants, five secondary challenging behaviour topographies were attributed a demand escape function following the concurrent analysis. All were suitable for further investigation. The summary plots of these behaviours are shown in Figure 4.5 and labelled with the letters A to E. All five behaviours showed an increasing level of demand prior to their onset. For four behaviours (A, C, D, E) the highest probability of demand in the antecedent period occurred directly prior to their onset. For two behaviours (A, B) there was a decreasing level of demand following their onset. For three behaviours (A, B, D) there was a substantial overall decrease in demand during the period following their offset compared to the period before their onset. In summary, one behaviour (A) demonstrated a profile consistent with all four features of a negative social reinforcement process, two behaviours (B, D) demonstrated three features and two behaviours (C, E) demonstrated two features.

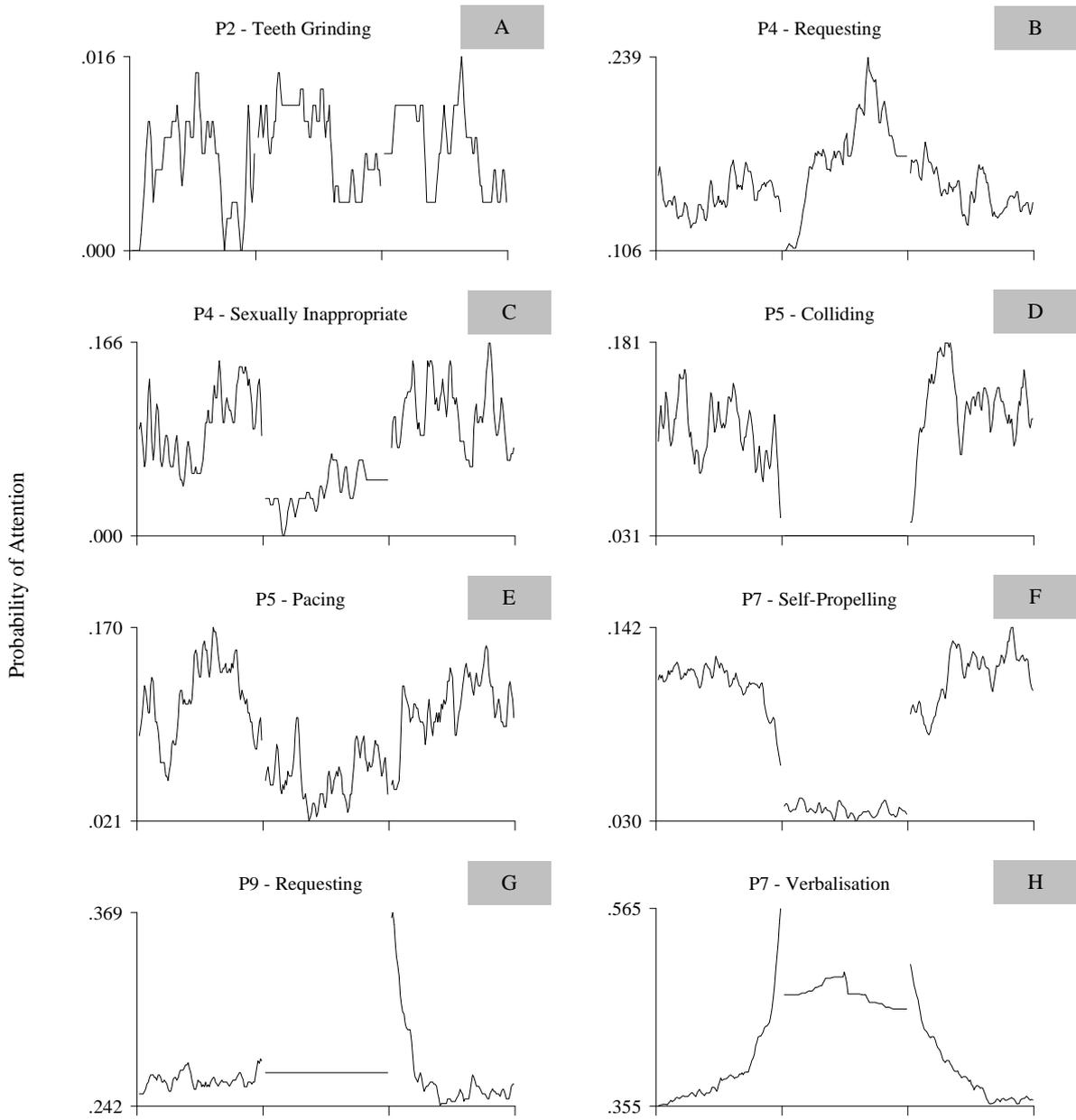
Following the concurrent analysis, across all participants, eight secondary challenging behaviours were attributed an attention maintained function. *Pacing* by participant 2 occurred too infrequently to be included in the analysis. The summary plots of the analysed behaviours are shown in the first seven panels of Figure 4.6, which are labelled A to G. Three behaviours (D, E, F) showed a decreasing level of attention prior to their onset. For two behaviours (D, F) the lowest probability of attention in the antecedent period occurred directly prior to their onset. Two behaviours (B, E) exhibited a pattern of increasing attention level following onset. For one behaviour (F) there was a substantial overall increase in attention following their offset compared to the period before their onset. In summary, one behaviour (F) demonstrated a profile consistent with three features of a positive social reinforcement, two behaviours (D, E) demonstrated two features and four behaviours (A, B, C, G) demonstrated one or zero features.

Only one behaviour was attributed a social escape function following the concurrent analysis. It was thought to have been maintained by a process of negative reinforcement. The summary plot for this social escape behaviour is labelled H in Figure 4.6. An increasing level of social contact was recorded prior to the onset of the behaviour. The highest level of social contact in the antecedent period occurred directly prior to its onset. A decreasing pattern of social attention was shown following the onset of the behaviour. Furthermore a substantial overall decrease in social attention was exhibited following the offset of the behaviour compared to the period before its onset. In summary, the behaviour (H) displayed all four features expected of a negative social reinforcement process.



Percentiles of Time Units Before, During and After the Secondary Challenging Behaviour

Figure 4.5 Probability of staff demand occurring at each percentile in the periods before, during and after secondary challenging behaviours



Percentiles of Time Units Before, During and After the Secondary Challenging Behaviour

Figure 4.6 Probability of staff attention occurring at each percentile in the periods before, during and after secondary challenging behaviours

4.3.3.3 Summary

The results from the concurrent and sequential analyses are summarised in Table 4.17. Across all participants, three secondary challenging behaviours did not demonstrate any association with an environmental event. In the other thirteen cases a behavioural function was attributed to the challenging behaviour using the concurrent analysis method. One behaviour served two functions. It was reinforced by a process of both positive and negative reinforcement. Four pairs of behaviours that each served an identical function were exhibited by three participants. The findings of the concurrent analyses were not corroborated in five instances. Four findings were contradicted by the sequential analyses and one was not analysed due to an insufficient number of behavioural bursts. Overall, 64% ($n = 9/14$) of concurrent analyses results were corroborated by the results of the sequential analyses. The results of both methods differed 29% of the time ($n = 4/14$). A comparison of methods was not possible for 7% of cases ($n = 1/14$). If these instances were disregarded, across all evaluated findings, the concordance rate between concurrent and sequential analysis methods was 69% ($n = 9/13$).

Table 4.17 Function of secondary challenging behaviours derived from concurrent and sequential analyses

		Participants and their Exhibited Secondary Challenging Behaviours																	
Function	Analysis Method	1	2			3	4			5			6	7		8	9		
		Sex.In	Flail	Pace	Teeth	–	Req	Sex.In	Touch	Coll	Pace	Verb	Persev	S-prop	Verb	Sex.In	Req	Sex.In	
Social	Concurrent	0	0	0	0		0	0	0	0	0	0	0	0	+	0	0	0	
Escape	Sequential	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	+	n.a.	n.a.	n.a.	
Social	Concurrent	0	0	+	+		+	+	0	+	+	0	0	+	0	0	+	0	
Attention	Sequential	n.a.	n.a.	i.d.	–		–	–	n.a.	+	+	n.a.	n.a.	+	n.a.	n.a.	–	n.a.	
Demand	Concurrent	0	+	0	+		0	0	+	0	0	+	+	0	0	0	0	0	
Escape	Sequential	n.a.	+	n.a.	+		n.a.	n.a.	+	n.a.	n.a.	+	+	n.a.	n.a.	n.a.	n.a.	n.a.	

Key:

- 0 Function not apparent
+ Function revealed
– Function not confirmed by sequential analysis
i.d. Insufficient data to conduct sequential analysis
n.a. Sequential analysis not conducted as function not apparent

Abbreviations:

- Coll Colliding
Flail Flailing
Pace Pacing
Persev Perseverating
Req Requesting
Sex.In Sexually inappropriate
S-prop Self-propelling
Teeth Teeth grinding
Touch Touching
Verb Verbalising

4.4 DISCUSSION

The purpose of this study was to apply a detailed descriptive analysis of clinically significant challenging behaviours shown by traumatic brain injury survivors. The aim of the study was to determine whether challenging behaviours exhibited by survivors of traumatic brain injury were functional. The temporal relationships between challenging behaviours and environmental events were explored to examine whether they adhered to a social model of reinforcement. This was achieved by using different forms of descriptive analysis methodology. Such functional assessments have been infrequently applied in the brain injury literature. The recording techniques adopted in this study were fine grained, extensive and encompassed a wide range of observable events. Novel recording techniques enabled various analyses to be conducted at a detailed level. Individual challenging behaviour topographies were assessed by coding the discrete forms of the exhibited behaviours. Specific aspects of staff behaviours were coded to provide additional information to that yielded from the generic demand and attention variables. In addition to the traditional aggressive behaviours, this study also focused on other challenging behaviours that were targeted as long-term clinical objectives. Overall, findings showed a variety of concurrent and sequential relationships between challenging behaviours and environmental events.

The principle aim of the study was to establish whether environmental determinants of challenging behaviours existed. Consequently, the associations between primary challenging behaviours and environmental events were explored. The concurrent analysis showed that the majority (88%) of primary challenging behaviours ($n = 21/24$) were significantly likely to co-occur with at least one environmental variable. The presumed antecedent and the possible function of the challenging behaviours were deciphered from the results of the concurrent analyses. Behavioural function was inferred by examining variations in the probability of challenging behaviours occurring in response to different social events (e.g. Repp & Karsh, 1994a; Emerson *et al.*, 1996). All significant and non-significant associations were interpreted using a fixed set of rules. The results were deciphered in terms of socially mediated reinforcement processes. All significant findings were conceptualised in terms of either positive social reinforcement, negative reinforcement in the form of demand escape or negative reinforcement in the form of social escape. All participants exhibited at least one primary challenging behaviour that was functional. Across all participants, no behaviours served the function of escaping social attention, a demand escape function was

attributed in thirteen cases and gaining social attention emerged as the behavioural function in thirteen cases.

The associations between secondary challenging behaviours and environmental events were also examined, in addition to those relating to primary challenging behaviours. These secondary challenging behaviours were non-aggressive responses that were targeted as long-term rehabilitative goals. This investigation was a novel area of analysis in the brain injury literature. This study was foremost in considering challenging behaviours as both aggressive and non-aggressive responses. The concurrent analysis showed that the majority (81%) of secondary challenging behaviours ($n = 13/16$) were significantly likely to co-occur with at least one environmental event. Across all participants, one behaviour was attributed an attention escape function, eight behaviours served the function of gaining social attention and the behavioural function of escaping demands emerged in five cases.

There were only three instances of a (secondary) challenging behaviour with no significant association with an environmental event. Interestingly, in all three cases the challenging behaviour was the same. The *sexually inappropriate* behaviours exhibited by participants 1, 8 and 9 were all found to be unrelated to an environmental event. As such they were ascribed no behavioural function. Given the nature of this problematic behaviour and its independence from environmental events, it seems likely that these *sexually inappropriate* behaviours were maintained by automatic reinforcement. This type of positive self-reinforcement process was not considered in the study. This may indicate a weakness in the interpretation process of the concurrent analysis. However to claim an internal behavioural function on the basis of undifferentiated responding would have been difficult to legitimise. Although given such a claim would have emerged for three independent cases of *sexually inappropriate* behaviour was interesting.

Assertions of function that were derived solely from the concurrent analysis lacked validity. All such interpretations were suppositions based on correlational data. So, additional support for the function of challenging behaviours was provided by the sequential analysis. Its purpose was to examine whether appropriate sequential relationships between functional behaviours and their reinforcing consequences existed. A sequential analysis, using the normalise-and-pool method, was used to examine the distribution of the environmental events in relation to the occurrence of each challenging behaviour. This involved the standardisation of periods of time in order to calculate the conditional probabilities of social stimuli occurring at each percentile interval before, during and after the occurrence of challenging behaviour. A pattern of responding that exhibited two or more features expected of a social reinforcement model was considered sufficient to verify the function of behaviour (Hall & Oliver, 1997;

2000). The interpretations of function based on concurrent relationships were mostly substantiated by the results of the sequential analysis. The behavioural functions of primary and secondary challenging behaviours, derived from the concurrent analyses, were not explicitly supported by the sequential analyses in only 8% and 29% of cases, respectively.

The descriptive analyses conducted in this study, using both concurrent and sequential analyses, suggest that challenging behaviours shown by brain injury survivors do not occur randomly. The findings promote the view that challenging behaviour is a functional, orderly and predictable response (Yody *et al.*, 2000). This conceptualisation of challenging behaviour, which adheres to the behavioural model, as described in section 1.7.3, is commonly adopted in the intellectual and developmental disabilities literature (Carr, 1994; Derby *et al.*, 1994; Oliver, 1995). The main pronouncement of the study is that challenging behaviours shown by various population groups are similar in form and function. The conclusion that challenging behaviours are socially mediated operants extends the limited research within the brain injury literature, which has also illustrated escape motivated challenging behaviours (Slifer, Cataldo, & Kurtz, 1995; Manchester *et al.*, 1997; Mozzoni *et al.*, 2000) and attention motivated challenging behaviours (Manchester *et al.*, 1997). Consequently, the findings of the study would indicate that challenging behaviours shown by brain injury survivors may be managed and modified using treatment methods based on principles of operant conditioning (Miltenberger, 2000). This suggestion concurs with studies that have successfully implemented behavioural modification treatments with the brain injury population, using reinforcement (Wood, 1984; Wood *et al.*, 1988), punishment (Alderman, 1991; Peters, Gluck, & McCormick, 1992) and extinction procedures (McMillan, Papadopoulus, Cornall, & Greenwood, 1990; Davis, Turner, Rolider, & Cartwright, 1994). The operant model of challenging behaviour described in this study is concordant with the overall findings of the empirical meta-analysis study presented in Chapter 3. This work showed that intervention strategies using behavioural modification procedures have been used effectively in treating challenging behaviours.

The results of this study found that five participants showed a primary challenging behaviour that was elicited by more than one antecedent. As such these were deemed to serve multiple functions. The *self-injury* of participant 4, the *physical aggression* exhibited by participant 9 and the *verbal aggression* presented by participants 2, 5 and 7 were all reinforced by both social attention and the removal of demand. *Teeth grinding*, a secondary challenging behaviour, shown by participant 2 was also found to be occasioned by more than one environmental stimulus. A potential threat to the validity of these findings was that they were not all supported explicitly by a sequential analysis. In most cases the sequential

analyses were not conducted due to insufficient numbers. On the basis of uncorroborated correlational data, these challenging behaviours seemed to be maintained by both positive and negative reinforcers. The findings potentially support other studies that have illustrated challenging behaviours can be maintained by more than one mechanism (Haring & Kennedy, 1990; Durand & Carr, 1991; Smith, Iwata, Vollmer, & Zarcone, 1993; Day, Horner, & O'Neill, 1994; Iwata *et al.*, 1994c; Kennedy, Meyer, Knowles, & Shukla, 2000). The existence of individual topographies with differential reinforcement contingencies has important clinical implications for treatment. Multifunctional challenging behaviours may explain why an intervention procedure may lead to only a partial reduction of the target behaviour. The multiple functions associated with a challenging behaviour mean that complex behavioural interventions may be needed, to account for the topography being occasioned and maintained by more than one social stimulus. As such, different intervention procedures are required to address each of the multiple functions of the challenging behaviour (Carr & Carlson, 1993; Day, Horner, & O'Neill, 1994). The study findings have shown that a comprehensive descriptive analysis, conducted across a range of observational contexts, can uncover the presence of challenging behaviours that serve multiple functions. Consequently, the descriptive analysis approach adopted in this study has great clinical utility because it can influence the design and effectiveness of intervention strategies.

Overall, the findings of this study have shown that a descriptive analysis methodology can be used to conduct a comprehensive assessment of function with brain injury survivors. Moreover, this functional assessment technique can reveal challenging behaviours that serve both single and multiple functions. Nevertheless, the main limitation of the study concerns the length of time taken to collect the data and the procedure for terminating recordings. First, a large quantity of observational data was collected for each participant. As such the duration of the observations conducted in this study may be prohibitory for a clinician. The proposed observational technology would have had greater utility as a clinical assessment tool if the cost of administration was reduced. Second, the frequency and duration of each observational session was not established by any formal criteria. Recordings were terminated on the basis of subjective appraisals that sufficient data had been collected for meaningful results to emerge. The robustness of the study is restricted by the absence of any formal procedure for the cessation of observations, as it means the work cannot be replicated exactly. Given the study data, it may have been the case that statistically meaningful findings would have emerged anyway from shorter observation periods. A future study could use the data set and repeat the analyses using only data from a randomly selected group of observation sessions or from the first batch of observation sessions collected.

Alternatively, future studies may conduct a similar investigation but with a reduced total observation time that is pre-determined.

Various proposals for future areas of research emerge from this study. As discussed previously, the form and function of challenging behaviours presented by traumatic brain injury survivors are similar to those seen in the intellectual disabilities population. This means that functional assessment methodologies, applied behaviour analysis techniques and clinical interventions used for the intellectual disabilities population could potentially be generalised to the field of neurorehabilitation. The intellectual disability literature has been increasingly focusing on the relationship between cognitive impairments and challenging behaviour. The connection between impaired cognitive functioning and challenging behaviour has not been extensively researched in the brain injury literature despite being broadly accepted amongst clinicians. This is surprising given that cognitive deficits are a common consequence of brain injury (Schretlen & Shapiro, 2003). For instance, reduced inhibitory control, memory loss and problem solving difficulties may be factors that increase the likelihood of challenging behaviours. Additional areas of interest in the intellectual disabilities concern the interaction between challenging behaviours and setting events, such as sleep deprivation, menstruation and mood. The brain injury field may similarly benefit from more extensive research into the neurological underpinnings of challenging behaviour. These contributory factors should set the general context for functional assessments and inform ongoing neurorehabilitation efforts. The technology used in this study can not only analyse social determinants of challenging behaviours but it can also account for other neurological, cognitive and emotional factors. Such data can be input into the handheld computer and all analyses can be conducted in the context of such factors.

Neurobehavioural approaches should also concentrate on the influence of language impairments on challenging behaviours. Within the field of intellectual disability, the link between communicative behaviours and challenging behaviours has been well established (Oliver *et al.*, 1999). Functional communication training has been an influential intervention approach (Carr *et al.*, 1985; Durand, 1990). Functional equivalence training involves learning an adaptive communicative response that is an efficient, functionally equivalent alternative to the challenging behaviour. The alternative communicative behaviour can take the form of vocalisations (Durand & Carr, 1991), manual signing (Horner & Day, 1991), picture communication symbols (Kahng, Hendrickson, & Vu, 2000) or assistive communicative devices (Durand, 1999). Clinical strategies have been used in neurorehabilitation settings to enhance social communication skills (Godfrey & Shum, 2000; Shelton & Shryock, 2007; Dahlberg *et al.*, 2007). However, little empirical research has been conducted with those with

severe aphasia who need compensatory communication systems (Coelho, 1987). A comprehensive descriptive analysis, similar to that conducted in this study, can decipher the communicative function served by challenging behaviour. This provides the ideal starting point from which to introduce functional communication training for traumatic brain injury survivors.

CHAPTER 5 SECONDARY ANALYSIS

5.1 INTRODUCTION

The findings of the descriptive analysis study, in Chapter 4, clearly indicated challenging behaviours shown by traumatic brain injury did not occur indiscriminately. Rather than being independent phenomena, challenging behaviours were associated with environmental stimuli. Challenging behaviours were found to frequently follow environmental stimuli. The results of the study found all participants presented at least one challenging behaviour that was significantly associated with an environmental event. Moreover, in some cases, there was evidence to suggest the challenging behaviours adhered to a mutual reinforcement hypothesis. An important discovery in the study was that some participants presented multiple behaviours that were evoked by the same antecedent conditions and reinforced by identical consequences. Such behaviours with functional equivalence are said to form one response class.

Theoretical accounts have been proposed to explain why a particular member of a response class may occur in preference over another member. It is important to understand the theoretical processes that govern how behaviour is distributed across two or more simultaneously available schedules of reinforcement. Matching theory is a mathematical model that conceptualises behaviours to be governed by a 'choice' of concurrent schedules of reinforcement. Any behaviour and its contingent reinforcement are conceptualised as one option amongst an array of alternative responses that each have their own associated reinforcement schedules. The 'selection' relates to the distribution of behaviour across two or more simultaneously available schedules of reinforcement (Myerson & Hale, 1984). The concern of matching theory is to ascribe why and how one response should be 'elected' in preference to other available responses. This is done by devising quantitative statements about the relationship between the controlling contingencies of multiple responses that are concurrently available (Fuqua, 1984). Matching theory is a theoretical account that is laboratory based with nonhumans (Fisher & Mazur, 1997). However, this research model has been adopted in applied settings to understand this concept of response choice of operants (Pierce & Epling, 1995).

Investigations have examined the extent to which parameters that influence response allocation in basic experiments are applicable with clinical populations (Fisher, Thompson, Piazza, Crosland, & Gotjen, 1997). Such research pertains to the allocation of a response from a response class of functionally equivalent behaviours. The selected response is that which is

most effective in engendering its reinforcing outcome. Response efficiency is determined by three factors: (i) the physical effort required, (ii) the reinforcement schedule, and, (iii) the duration until the reinforcer is delivered (Horner *et al.*, 1991). Matching law research conducted in applied settings have supported that response choice is determined by response effort (Horner, Sprague, Obrien, & Heathfield, 1990), rate and quality of reinforcement (Neef, Mace, Shea, & Shade, 1992) and immediacy of reinforcement (Neef, Mace, & Shade, 1993). Examination of the relationship between reinforcement and response rates is more complex in natural settings. Basic matching research involves two topographically identical responses that produce the same reinforcing consequence but which differ only in terms of their reinforcement schedules. However the concurrent schedules in naturalistic environments do not match these theoretical experimental specifications. In real world settings, competing responses are topographically dissimilar and undergo different reinforcement schedules that are quantitatively and qualitatively different (Myerson *et al.*, 1984). So asymmetrical choice situations are to be expected in applied settings.

The contention that response members are not subject to the same schedules of reinforcement has been described by Oliver (1995). This paper proposes a link between the efficiency of a behaviour and its aversive properties. It is stated that behavioural repertoires may include both adaptive and maladaptive responses that are functionally equivalent. However, despite having access to functionally equivalent adaptive responses, individuals are more likely to engage in maladaptive behaviours (Oliver *et al.*, 1999). In terms of the response efficiency parameters (Horner *et al.*, 1991), challenging behaviours are more likely to evoke a reinforcing outcome easily, consistently and quickly. This is ensured only because of the aversive qualities of challenging behaviours. The aversive nature of challenging behaviours means that caregivers are more likely to provide the participant with frequent and immediate reinforcing consequences. According to the mutual reinforcement hypothesis (Oliver, 1995), since these reactions, in turn, result in the termination of the aversive stimuli (the challenging behaviours) then caregivers are also more likely to repeat their (re)actions.

Response efficiency research has focused mainly on its application to intervention techniques, based on functional equivalence training. As discussed in Chapter 2, one intervention goal of applied behaviour analysis is to teach the use of adaptive (communication) responses that are functionally equivalent to the maladaptive behaviour (Carr *et al.*, 1985; Durand, 1990; 1999). However, response efficiency may account for failures in attempts to teach functionally equivalent responses. The success of functional communication training is determined by the fact that the adaptive replacement behaviour has to be more efficient than the challenging behaviour it seeks to replace (Horner *et al.*, 1990).

Direct comparisons of low-efficiency and high-efficiency communicative alternatives have shown that challenging behaviours were significantly reduced only when efficient alternatives were taught (Horner et al., 1991).

According to matching theory, the allocation of functionally equivalent behaviours is linked to response efficiency. In terms of organisation of behaviours, the first allocated response is that with the most favourable schedule of reinforcement. Various authors have described the notion of a response hierarchy. According to Baer (1981), the most prominent responses within a response class hierarchy are those with the best combination of reinforcement schedules, least effort and lowest probability of punishment. Response class members have been found to occur in sequence, with the most effortful responses tending to occur later in the sequence (Lalli, Mace, Wohn, & Livezey, 1995). Scotti and colleagues (Scotti, Evans, Meyer, & DiBenedetto, 1991a) also posited a hierarchical organisation of behaviours in which more challenging responses occurred in the repertoire but at a lower probability of occurrence. Evans and colleagues (Evans, Meyer, Kurkjian, & Kishi, 1988) also conceptualised responses within a hierarchy in terms of probability, with the most frequent response having the highest probability of occurrence. This view of hierarchical sequences implies that if a high probability, low aversive response is subjected to extinction then a less probable and more aversive response would be expected to occur in its place (Magee & Ellis, 2000). A number of studies have adopted extinction procedures and found support for this contention (Richman, Wacker, Asmus, Casey, & Andelman, 1999; Harding *et al.*, 2001).

Clearly, there are problems associated with evoking serious challenging behaviours topographies in order to establish its functional properties. An alternative methodology is proposed by Smith and Churchill (2002). These authors have suggested that information regarding the function of challenging behaviours can be gained indirectly by placing contingencies on benign behaviours that may belong to the same response class. They used informal direct observation and anecdotal information provided by caregivers to identify precursor behaviours, which regularly preceded the occurrence of challenging behaviours. Experimental analysis contingencies were successfully applied to precursor behaviours. In this way, the function of precursors and challenging behaviours were identified accurately, even though the occurrence of challenging behaviours was prevented. Using precursor behaviours to assess behavioural hierarchies has been adopted in descriptive analysis (Borrero & Borrero, 2008) and experimental analysis (Richman, Wacker, & Winborn, 2001; Borrero *et al.*, 2008). Using precursor behaviour to assess function of challenging behaviour and to identify response hierarchies is a safe and less ethically contentious approach. Its benefits may

extend to clinical settings by providing a way for caregivers to attend to benign behaviours and prevent the occurrence of challenging behaviours.

The purpose of the first study is to identify the organisation of challenging behaviours. This shall be achieved by examining the structure of response classes by using time-based sequential analyses of descriptive data. First, this will involve a comparison of conditional probabilities of functionally equivalent challenging behaviours in relation to the establishing operation. This analysis shall determine whether response classes were structured randomly, sequentially or hierarchically. Second, an additional analysis of the relationships between primary and secondary challenging behaviours will also be undertaken. The purpose of this investigation is to discover the relative relationships between these challenging behaviour types. The goal is to establish whether the primary challenging behaviours acted as precursors to secondary challenging behaviours or vice versa, or whether the two were unrelated. Lastly, specific component behaviours that make up each challenging behaviour topography will be examined for evidence of any response patterns within each topographical class. The first study is not merely an esoteric exercise to understand the organisational structure of functionally equivalent operants. Even though the examination of response class structures is a technical field of inquiry, it was believed that the study would be pertinent for neurorehabilitation.

The objective of the second study is to relate the theoretical findings to be relevant in a clinical setting. This work shall seek to summarise the results of all findings so as to provide valuable information for neurobehavioural clinicians. To this end, an additional area of analysis shall also be conducted. This inquiry relates to the use of management procedures that rely on punishment techniques, such as restraint and time-out. Sequential analysis procedures were used to assess the effects of these procedures on the behaviours that they were designed to reduce. The descriptive data were also examined to see whether the procedures caused collateral increases in any other behaviours. All the information from all these different analyses, including those in Chapter 4, was encapsulated in a concluding chronicle for each participant. The analysis shall be conducted at the level of the behaviour and then to conclude a synthesis of the data at the participant level will be undertaken to summarise the clinical implications. As such, a concluding chronicle shall be created for all the findings that emerged in each case study.

5.2 METHOD

5.2.1 *Participants*

Details of the study participants are provided in section 4.2.1.

5.2.2 *Procedure*

Details of the procedures followed in this study are provided in section 4.2.2.

5.2.3 *Observer Agreement and Response Definitions*

Details of the response definitions of observed variables and the observer agreement achieved are provided in section 4.2.3.

5.2.4 *Data Analysis*

5.2.4.1 *Study 1 - Organisation of Challenging Behaviours*

The first objective of the study was to identify the nature of various relationships between challenging behaviours. The first inquiry concerned the relationships between functionally equivalent primary challenging behaviours. Behaviours with functional equivalency are said to form one response class, which is evoked by the same antecedents and reinforced by identical consequences. The aim was to characterise the organisation of the response class and establish whether response class behaviours were sequentially, hierarchically or randomly ordered. The analysis conducted in this regard followed from the results that emerged in section 4.3.2 and section 4.3.3 of the previous chapter. The occurrence of response class members, as indicated by the findings of the previous study, in relation to the establishing operation was investigated. The second inquiry involved the association between primary and secondary challenging behaviours. The aim was to uncover whether one behaviour type served as a precursor to another. The investigation was to establish whether functionally equivalent challenging behaviours of all types were temporally linked. The third inquiry related to the nature of specific behaviours that made up a challenging behaviour topography. The aim was to ascertain whether composite behaviours within a topography exhibited any responding patterns. This was achieved by examining the relationships between the most prevalent form of the topography and the other composite behaviours.

These inquiries into three aspects of interrelationships between challenging behaviours were assessed. All assessments were conducted using sequential analyses. A time-based lag sequential analysis method was used in all cases. This specific sequential analysis model fulfilled the objectives of determining the temporal links between behaviours (Emerson *et al.*, 1995; 1996; Forman, Hall, & Oliver, 2002; Millichap *et al.*, 2003). A

time-based lag sequential analysis calculated the conditional probability of a variable occurring at specific points in time in relation to another variable. The time frame of the analysis could be varied, to span from contiguous to remote associations. The reference points could be altered so that calculations were made from the onset, offset or occurrence of either variable. The parameters of the procedure used reflected the aims of the specific investigation. A slightly different method was adopted according to the interrelationship under examination.

The first inquiry concerned the organisation of the behaviours in a response class. The analysed behaviours were those with identical maintaining processes. This was established by the results of the concurrent and sequential analyses, as presented in section 4.3.2. The concurrent analysis provided a preliminary insight into the potential operant contingencies of behaviours. Support for these findings was determined by the normalise-and-pool technique. Any behavioural function contradicted by this supplementary investigation was dismissed from the time-based lag sequential analysis. All findings that were not explicitly contradicted were included. This included those that were not corroborated because insufficient data prevented an analysis using the normalise-and-pool technique. In these cases the accuracy of the functions derived from the concurrent analysis was inferred. Once the members of the response class were determined, the probability of all functionally equivalent behaviours occurring in relation to the establishing operation was calculated. The outcome of each lag sequential analysis was presented individually on a summary graph. The conditional probability of the behaviour occurring at a particular point was represented on the y-axis. The time periods before and after the independent variable were represented on the x-axis. The independent variable was the onset of demand for behaviours that served a demand escape function. The stimulus was more obscure for response classes maintained by positive reinforcement in the terms of 'attention soliciting'. In such cases the establishing operation was determined to be the deprivation of attention. The analysis was conducted in relation to the offset of the attention variable. All analyses were conducted in terms of three second units, which matched the three second time intervals used in the interobserver agreements calculations. The conditional probabilities were calculated between lags -10 to +10, where each lag from the independent variables represented three seconds. Hence the temporal window of the analysis was set at 30 seconds before and after the relevant stimuli.

The second area of analysis involved the association between primary and secondary challenging behaviours. The analysed behaviours were functionally equivalent. This was established from the results of the concurrent analyses, as presented in section 4.3.3. A time-based lag sequential analysis was used to examine the interconnections. The likelihood of the secondary challenging behaviour occurring in relation to the primary challenging

behaviour was calculated. The independent variable was the onset of the primary challenging behaviour. The time periods before and after the independent variable were represented on the x -axis. The conditional probability of the dependent variable occurring was gauged using the Yule's Q index and represented on the y -axis. The outcome of each lag sequential analysis was presented on a separate graph. All analyses were conducted in terms of three second units, which matched the time intervals used in the interobserver agreements calculations. The conditional probabilities were calculated between lags -40 to $+40$, where each lag from the independent variables represented three seconds. Hence, the temporal window of the analysis was set at 120 seconds (two minutes) before and after the discriminative stimulus.

The third area of analysis related to the associations between composite behaviours within a challenging behaviour topography. The analysed behaviours were all those that made up each topography. A time-based lag sequential analysis was used to examine the inter-relationships between them. The independent variable was the onset of the most prevalent form of the topography, which was arbitrarily considered to be dominant. The dependent variable was each other composite behaviour within the topography. The likelihood of a specific behaviour occurring in relation to the dominant form of the topography was calculated. The time periods before and after the independent variable were represented on the x -axis. The conditional probability of the dependent variable occurring was gauged using the Yule's Q index and represented on the y -axis. All analyses were conducted in terms of three second units. This corresponded to the time intervals used in the interobserver agreements calculations. The conditional probabilities were calculated between lags -20 to $+20$. Each lag from the independent variables represented three seconds. The temporal window of the analysis was therefore 60 seconds (one minute) before and after the onset of the dominant form of the topography.

5.2.4.2 *Study 2 - Evaluation of Management Programmes*

An analysis of clinical response programmes was conducted. The inquiry sought to evaluate formalised staff procedures for managing challenging behaviours. The aim was to describe the effect of restraint and time-out / seclusion programmes on challenging behaviours. Analyses were conducted on not only the target behaviour but also on other topographies. The effectiveness of the programme to manage the occurrence of the target behaviour was examined. Moreover, the evaluation was concerned with whether such programmes inadvertently increased other challenging behaviours. Such evaluations were not functional assessments but they did involve some descriptive analysis techniques. The temporal relationships between occurrence of restraint and challenging behaviours were

assessed using sequential analyses. The effect of time-out procedures on challenging behaviour was gauged using occurrence rates during periods of seclusion.

A time-based lag sequential analysis was used to examine the relationship between restraint and challenging behaviours. The probability of the target behaviour and other topographies occurring at various times in relation to *restraint* was calculated. The probabilities were calculated 30 seconds before and after the discriminative stimulus, at ± 1 to ± 10 time lags of three seconds each. In relation to the period before and after, respectively, the independent variable was either the onset or offset of restraint. The time periods were represented on the *x*-axis. Conditional probabilities were shown on the *y*-axis using the Yule's Q index. Only meaningful findings were shown. The outcome of each analysis was graphed separately. The effect of seclusion on challenging behaviours was calculated through descriptive summaries of frequency. A filtered analysis of the frequency of behaviours during seclusion enabled comparisons with occurrence rates at other times.

5.2.4.3 *Summary of Data Analyses*

The analysis topics and methods used that relate to the investigation of the organisation of challenging behaviours and the evaluation of management procedures are summarised in Table 5.1.

Table 5.1 Summary of data analyses

Assessment	Analysis	Method	Variables	IV	DV	Outcomes
Organisation of behaviours	Response class	Sequential analysis: Time-based	Functionally equivalent primary CBs	Environment event	Response class members	Response class structure: hierarchical, sequential or random
	Primary CB vs. Secondary CB		Functionally equivalent primary CBs	Primary CB	Secondary CB	Sequence of primary and secondary CBs, i.e. the existence of precursors
	CB topographies		Component behaviours within a topography	Dominant behaviour	Non-dominant behaviours	Behavioural responding within a CB topography
Management programme	Restraint ¹	Sequential analysis: Time-based	Target behaviour and all others	Restraint	All CBs	Management programme effectiveness and inadvertent increased in other CBs

Abbreviations:

CB Challenging Behaviour

¹ The effect of seclusion was also considered by using descriptive statistics that filtered out periods of non-seclusion

5.3 RESULTS

The results pertaining to the organisation of behavioural repertoires are presented in this section. The findings of the time-based lag sequential analyses are presented first, which relate the intra- and inter-relationships between challenging behaviour types and topographies. Then findings of time-based lag sequential analyses and filtered descriptive statistics are presented, which relate the utility of clinical management programmes.

5.3.1 Study 1 - Organisation of Challenging Behaviours

5.3.1.1 Response Class Behaviours: Sequences and Hierarchies

The results are grouped according to the presumed establishing operation. Primary challenging behaviours maintained by demand escape are considered first. Then behaviours that served an attention seeking function are shown thereafter. The variables analysed were functionally equivalent behaviours within a participant's repertoire. These were determined by the results of the descriptive analyses, as presented in sections 4.3.2 and 4.3.3. The main findings of behaviour function are summarised in Table 4.15 and Table 4.17, respectively. The response class members contingent on demand and attention withdrawal are surmised in Table 5.2 and Table 5.3, respectively. These constructs were examined using a time-based lag sequential analysis. The results of the analyses are presented for each participant. The conditional probabilities of each response class member occurring at a particular time, in relation to the maintaining variable, are shown on the same graph. The graphs are grouped according to the eliciting stimuli. The lag sequential analysis graphs relating to demand contingent and attention maintained behaviours are contained in Figure 5.1 and Figure 5.2, respectively.

Table 5.2 Topographies maintained by demand escape

Participant	Primary Challenging Behaviours Serving a Demand Escape Function
2	Physical aggression, Verbal aggression*
4	Physical aggression*, Self-injury*
5	Property destruction, Verbal aggression
6	Physical aggression, Property destruction*, Verbal aggression
7	Physical aggression, Verbal aggression

Note: * function could not be substantiated by sequential analysis due to insufficient numbers

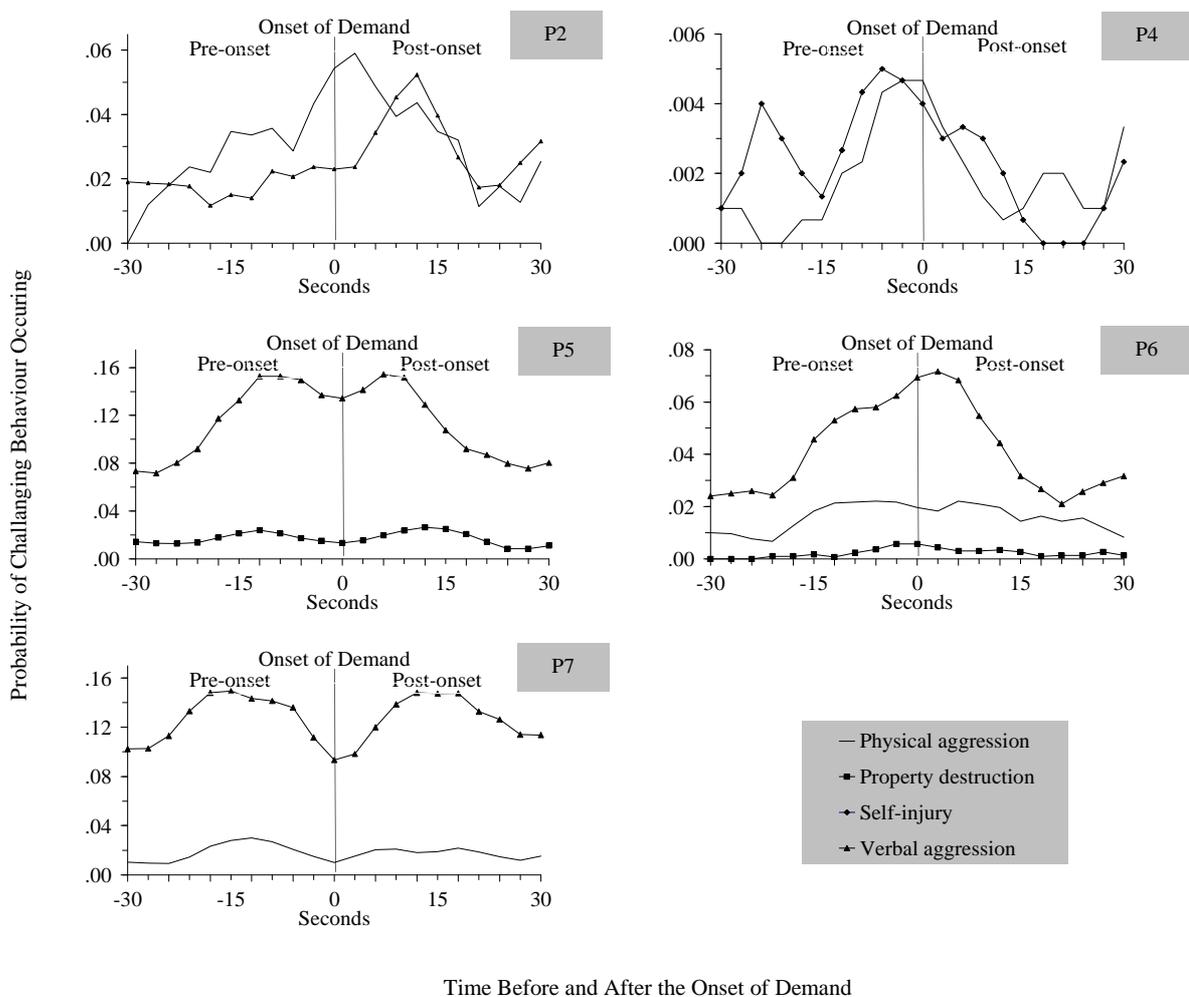


Figure 5.1 Probability of functionally equivalent primary challenging behaviours occurring before and after the onset of staff demand

A sequential pattern of responding was evident for some response classes that served a demand escape function. The functionally equivalent behaviours demonstrated by participant 2 and 4 were sequentially organised. For participant 2, both response class behaviours demonstrated highly comparable patterns of overall responding. The similar configurations of these behaviours were distinguished by a time interval between them. Their occurrence patterns would have been identical if not for a slight shift. A delay of approximately ten seconds separated the occurrence of *physical aggression* and *verbal aggression*, in the period contiguous to *demand*. *Physical aggression* preceded *verbal aggression*. After an initial plateau, the probability of *physical aggression* increased six seconds before the onset of *demand*, peaking three seconds after its onset and then diminished. *Verbal aggression* followed an identical pattern but its occurrence was temporally deferred. A similar account emerged for the response class of participant 4. In this case, the behaviours were more contiguous. *Physical aggression* followed *self-injury* by only three seconds, in the period prior to the onset of *demand*. Both demonstrated similar overall

responding patterns. The probability of *physical aggression* and *self-injury* both increased fifteen seconds prior to *demand* and peaked alike with the onset of *demand*.

A ranked pattern of responding emerged for some response classes, which were contingent on demands. The functionally equivalent behaviours demonstrated by participant 5, 6 and 7 were organised in a graded manner. A clearly distinguishable pattern of responding emerged in all cases. The probability of occurrence for each behaviour in the response class was ordered. So, despite serving the same function, some response class behaviours were more likely than others to be exhibited. In addition to being ordered, for participant 5 and 7, the responding patterns of all response class members were similar. Also the configurations in the period before and after the onset of *demand* were symmetrical. For participant 5, the probability of *verbal aggression* occurring at all times was unambiguously greater than that of *property destruction*. For participant 7, *verbal aggression* was more likely to occur than *physical aggression* at any time. The response class for participant 6 comprised of three members. At any point, *verbal aggression* was more likely than *physical aggression* to occur, which in turn was more probable than *property destruction*. The pattern of responding, which was clearly distinguishable, was more prominent in the 30 second period either side of *demand* onset.

Table 5.3 Topographies maintained by social attention

Participant	Primary Challenging Behaviours Serving an Attention Gaining Function
3	Physical aggression, Property destruction, Self-injury, Verbal aggression
4	Self-injury*, Verbal aggression*
7	Property destruction, Verbal aggression

Note: * function could not be substantiated by sequential analysis due to insufficient numbers

Some response class behaviours demonstrated a ranked pattern of responding. The attention maintained behaviours of participant 3 and 7 were organised in a hierarchical manner. A distinct and ordered pattern of responding emerged for these response class members. The likelihood of behaviours occurring differed at all times. Also the response pattern of each presented a symmetrical formation. Participant 3 presented four functionally equivalent behaviours that differed from each other in terms of occurrence. The probabilities of all the behaviours decreased prior to the offset of *attention*, reached near zero levels when *attention* terminated and increased again thereafter. The contrast in the magnitude of their probabilities changed exponentially with time. The behaviour most likely to be exhibited at all times was *verbal aggression*. After that the hierarchical order of the response class behaviours

was *self-injury*, *physical aggression* and then *property destruction*. Discrete patterns of responding were recorded also for the behaviours exhibited by participant 7. The likelihood of *verbal aggression* occurring was far greater than that for *property destruction* at all times. The probability of *verbal aggression* decreased and then increased in the fifteen second period before and after the offset of *attention*. The behaviour was least likely to occur at the offset of *attention*. No distinguishable model for the response class of participant 4 emerged. The behaviours were neither sequentially nor hierarchically organised.

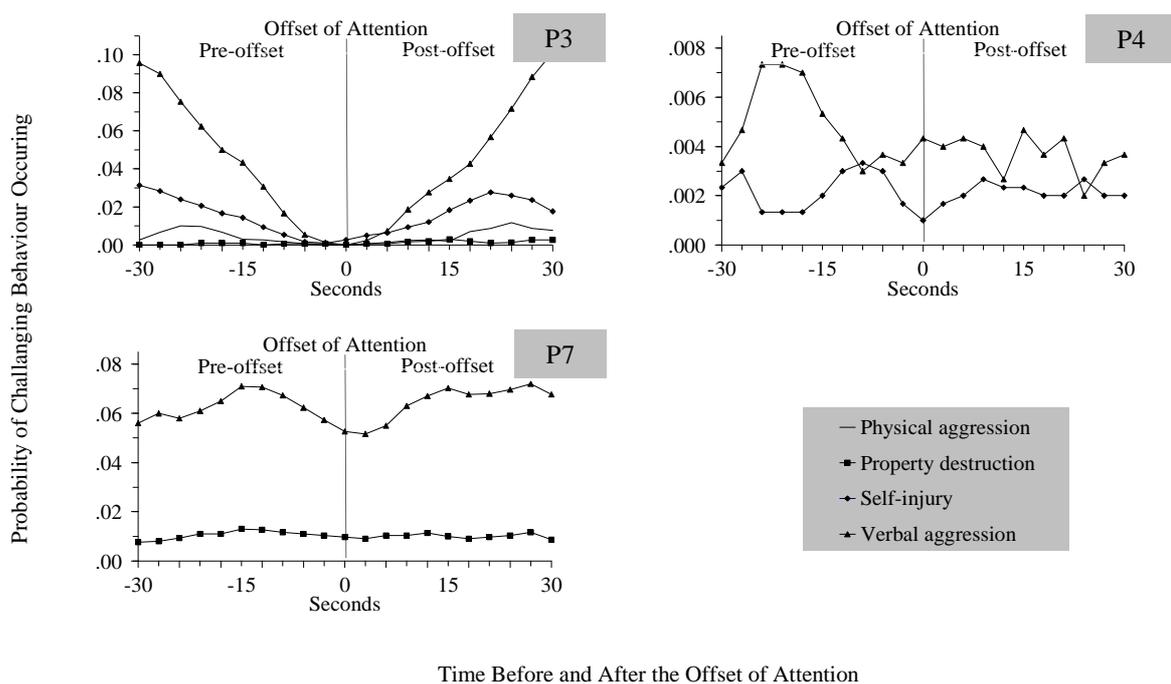


Figure 5.2 Probability of functionally equivalent primary challenging behaviours occurring before and after the offset of staff attention

5.3.1.2 Functionally Equivalent Challenging Behaviours

The variables analysed were functionally equivalent primary and secondary challenging behaviours within a participant's repertoire. All interrelationships were investigated using a time-based lag sequential analysis method. In total six secondary challenging behaviours showed no relationship with other functionally equivalent primary challenging behaviours. As described in section 5.2.4.1, only the meaningful outcomes are presented, in Figure 5.3. The probabilities of a secondary challenging behaviour occurring at particular times in relation to the primary challenging behaviour are shown in each graph.

Some secondary challenging behaviours were precursors to primary challenging behaviours. The *teeth grinding* and *flailing* exhibited by participant 2 preceded *verbal aggression* and/or *physical aggression*. The probability of *teeth grinding* increased in the

period before the onset of *physical aggression* and *verbal aggression*. In both cases, the likelihood of *teeth grinding* occurring reached its maximum at the onset of the primary challenging behaviour and then decreased thereafter. The rise and fall pattern in the occurrence probability continued throughout the pre- and post-onset period. The same pattern emerged between *flailing* and *physical aggression*.

Most secondary challenging behaviours followed the occurrence of primary challenging behaviours. The likelihood of secondary challenging behaviour increased after the onset of the primary challenging behaviour. For participant 5, the probability of *pacing* decreased throughout the period prior to *verbal aggression* and reached near zero levels at the point of its onset. After *verbal aggression* had occurred the likelihood of *pacing* occurring increased. This increase was dramatic in the first 30 seconds but continued throughout the post-onset period. A very similar pattern of responding emerged between the *self-propelling* and *verbal aggression* exhibited by participant 7. In the other cases the same configuration emerged but within a restricted time period. The decrease and increase either side of the primary challenging behaviour was very steep. This responding pattern was shown for the *verbalising* demonstrated by participant 5 in relation to *property destruction*. In the twelve seconds before and after the onset of *property destruction*, the probability of *verbalising* suddenly decreased to near zero levels and thereafter steeply increased. In some cases the probability of the secondary challenging was at its pinnacle directly prior to onset and then fell to its lowest level at the point of onset. This was true for two pairs of behaviours: *perseverating* and *verbal aggression* by participant 6; *self-propelling* and *property destruction* by participant 7. The relationship between *perseverating* and *physical aggression* exhibited by participant 6 was the most ambiguous. Nevertheless a similar overall pattern was recorded within the confines of the twelve seconds before and after the onset of *physical aggression*.

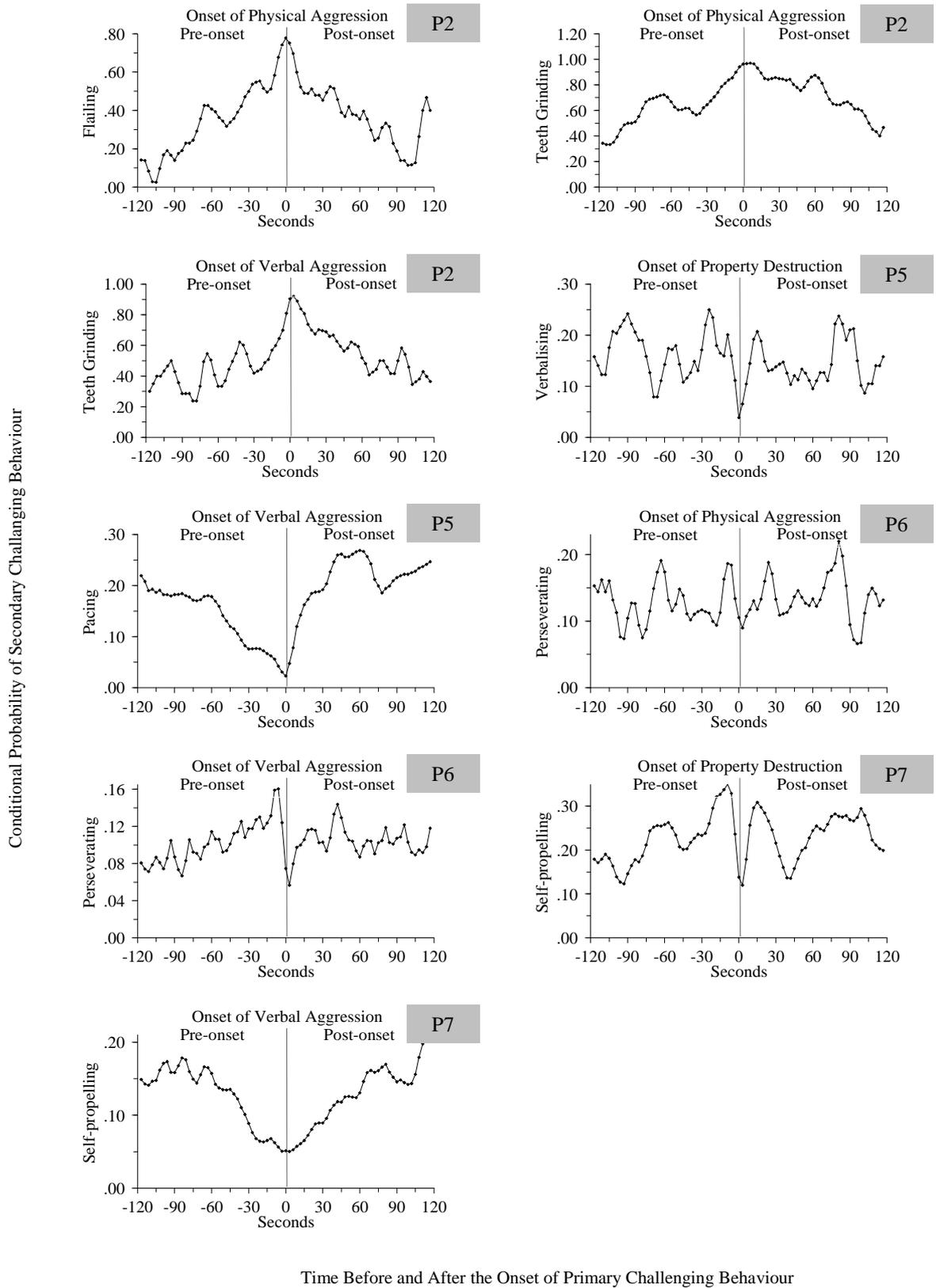


Figure 5.3 Probability of secondary challenging behaviours occurring before and after the onset of functionally equivalent primary challenging behaviours

5.3.1.3 *Responses within a Challenging Behaviour Topography*

With only three exceptions, the primary challenging behaviours exhibited by all participants comprised more than one form of the topography. For example, as shown in Appendix F, the *physical aggression* topography presented by participant 7 was made up of the following specific behaviours: *grabbing*, *hitting*, *kicking* and *punching*. The three exceptions related to the *verbal aggression* topography presented by participants 2, 4 and 5, which only took one form, namely, *mild outburst*.

Substantive results did not appear following the time-based sequential analysis, which examined the associations between the composite behaviours. No inter-relationships emerged between the different forms of each topography. The composite behaviours displayed no meaningful responding patterns.

5.3.1.4 *Summary*

Lag sequential analyses were used to investigate the organisation of participant responses. The relative differences in trends between conditional probabilities were compared. No standardised criterion of significance was applied in the analysis. As such, the evidence that suggested that challenging behaviours were related to each other in many ways was weak. Various inter- and intra-relationships between primary and secondary challenging behaviours emerged.

First, organised structures were found to exist between some primary challenging behaviours with identical maintaining processes. In some cases the functionally equivalent behaviours were nested or the response class members were ordered hierarchically or the probabilities of the behaviours occurring were distinct from each other. In other cases the behaviours were ordered sequentially. These behaviours were exhibited in a chronological manner. Not all response classes were organised in such ways. A random pattern emerged in a one instance.

Second, temporal associations were discovered between functionally equivalent challenging behaviour types. Some secondary challenging behaviours served as precursors to primary challenging behaviours. In other instances the opposite relationship was found. Not all challenging behaviour types were temporally linked however.

The last kind of relationship examined was that between responses within each challenging behaviour topography. No intra-relationships were found to exist between the different forms of each topography. The specific composite behaviours within each topography exhibited no pattern of responding.

5.3.2 Study 2 - Evaluation of Management Programmes

5.3.2.1 Restraining and Time-Out

All participants were eligible to being restrained as part of their management plan. Restraint was a programmed response by staff. The conditions necessary in order for participants to be restrained are briefly summarised in Table 5.4. The descriptive details of the restraint observed for each participant are also listed in the table. The extent to which participants were restrained differed. The frequency ranged from three to 75 and the mean duration varied from three seconds to 64 seconds. Participants 3 and 9 were restrained, respectively, for 13.7% and 7.8% of the total observation time. The other participants were restrained for less than 1% of the total time.

Table 5.4 Details of restraining management programme

Participant	Duration		Proportion of Total Time (%)	Frequency Onsets	Reason for Restraint
	Total (min, sec)	Mean (sec)			
1	0, 10	3.33	0.02	3	Physical aggression
2	9, 17	12.38	0.88	45	Physical aggression
3	79, 44	63.81	13.72	75	Self-injury
4	4, 39	4.04	0.31	69	Touching
5	3, 36	54.00	0.31	4	Property destruction
6	6, 28	16.87	0.44	23	Physical aggression
7	6, 50	13.23	0.58	31	Physical aggression
8	0, 15	3.75	0.03	4	Physical aggression
9	41, 5	42.50	7.84	58	Sexually inappropriate

Time-based lag sequential analyses were conducted to examine the relationship between restraint and challenging behaviours. The inclusion criterion for analysis was that the duration of *restraint* had to exceed 30 seconds. The results are presented in Figure 5.4. The data for participant 1 and 8 was not analysed on these grounds. In all other cases the challenging behaviour behind the management plan showed a meaningful relationship with *restraint*. Most participants engaged in further challenging behaviours as a consequence of *restraint*. However participants 4 and 6 did not exhibit other challenging behaviours as a result of *restraint*. Participant 4 was placed under *restraint* when *touching* behaviour was

exhibited. The probability of *touching* occurring increased sharply prior to *restraint* and then decreased thereafter. No other behavioural increases were recorded. The *restraint* programme devised for participant 6 was contingent on *physical aggression*. The probability of *physical aggression* increased sharply and reached its apex directly before the onset of *restraint*. Its probability returned to near zero levels nine seconds after the offset of *restraint*. No other behaviours were shown to increase in the period following *restraint*.

Restraint was used in response to the *physical aggression* exhibited by participant 2. The probability of *physical aggression* occurring was greatest directly prior to the onset of *restraint*. The likelihood of *physical aggression* occurring after the offset of *restraint* diminished only slightly overall. An inverted-u shaped pattern of responding emerged whereby the probability of *physical aggression* increased and then returned to its former level. After the offset of *restraint*, the probability of *verbal aggression* increased dramatically from near zero levels. A descriptive analysis of events during *restraint* periods showed that a third (35%) of all *verbal aggression* was exhibited during *restraint*.

The management plan for participant 3 involved both *restraint* and *seclusion*. *Restraint* was the programmed response to *self-injury*. The response to *physical aggression* was a negative punishment procedure that involved an exclusionary time-out (from positive reinforcement). The participant remained in *seclusion* until there was an absence of *physical aggression* for at least twenty seconds. However *restraint* was not used during *seclusion* periods and so the participant was able to freely engage in *self-injury*. The probability of *self-injury* was at its maximum directly prior to the onset of *restraint*. Following the offset of *restraint* the likelihood of *self-injury* decreased overall but not to zero levels. After 21 seconds the likelihood of *self-injury* increased. This may have reflected the occasions in *seclusion* in which *self-injury* was not prevented. The probability of *physical aggression* also increased after the offset of *restraint*. The participant engaged in specific forms of *physical aggression* that were amenable under *restraint*. A filtered descriptive analysis revealed that all instances of *kicking* ($n = 209$) and *pinching* ($n = 54$) occurred only when the participant was under *restraint*. Such *physical aggression*, which occurred in response to *restraint*, led to the participant being placed in *seclusion*. This in turn led to additional *self-injury* since it was not prevented during *seclusion*. Indeed over half (52%) of the total *self-injury* exhibited occurred during *seclusion*. The participant occupied nearly a quarter (24%) of *seclusion* time with *self-injury* and three-quarters (76%) with *verbal aggression*. In fact 45% of all *verbal aggression* occurred during *seclusion*.

Restraint followed by *seclusion* succeeded acts of *property destruction* by participant 5. The probability of *property destruction* increased dramatically prior to *restraint* and

reached its maximum level at the moment of its onset. The likelihood of *property destruction* being exhibited after the offset of *restraint* was zero. However, *verbal aggression* gradually increased prior to the onset of *restraint* and remained at a constant high level thereafter. This elevated probability may have reflected the occasions when the participant was placed in *seclusion*. The participant exhibited 7% of *verbal aggression* during *restraint* and 14% during *seclusion*. Indeed the majority of time in *seclusion* (75%) was spent engaging in *verbal aggression*.

The programme devised for participant 7 involved both *restraint* and *seclusion* in response to *physical aggression*. The probability of *physical aggression* increased sharply to reach its apex directly before the onset of *restraint*. Its probability returned to near zero levels fifteen seconds after the offset of *restraint*. In contrast to the continued cessation of *physical aggression*, the offset of *restraint* led to dramatic increases in *verbalising* and *self-propelling*. The *verbalising* that occurred during *seclusion* accounted for 17% of the total *verbalising* exhibited and occupied a third (34%) of the *seclusion* time.

The management plan for participant 9 involved both *restraint* and *seclusion*. *Restraint* was contingent on the presentation of *sexually inappropriate* behaviour. *Seclusion* was the programmed response to *physical aggression*. The probability of *sexually inappropriate* behaviour increased sharply prior to *restraint* and reached its maximum at the onset of *restraint*. The probability of *requesting* increased markedly in the period after the offset of *restraint*. Following an analysis of events during *restraint*, the likelihood of *physical aggression* jumped after the onset of *restraint*. *Physical aggression* occurring in response to *restraint* led to the participant being placed in *seclusion*. This in turn led to an escalated occurrence of verbal aggression. Indeed a third (34%) of all *verbal aggression* occurred during *seclusion*.

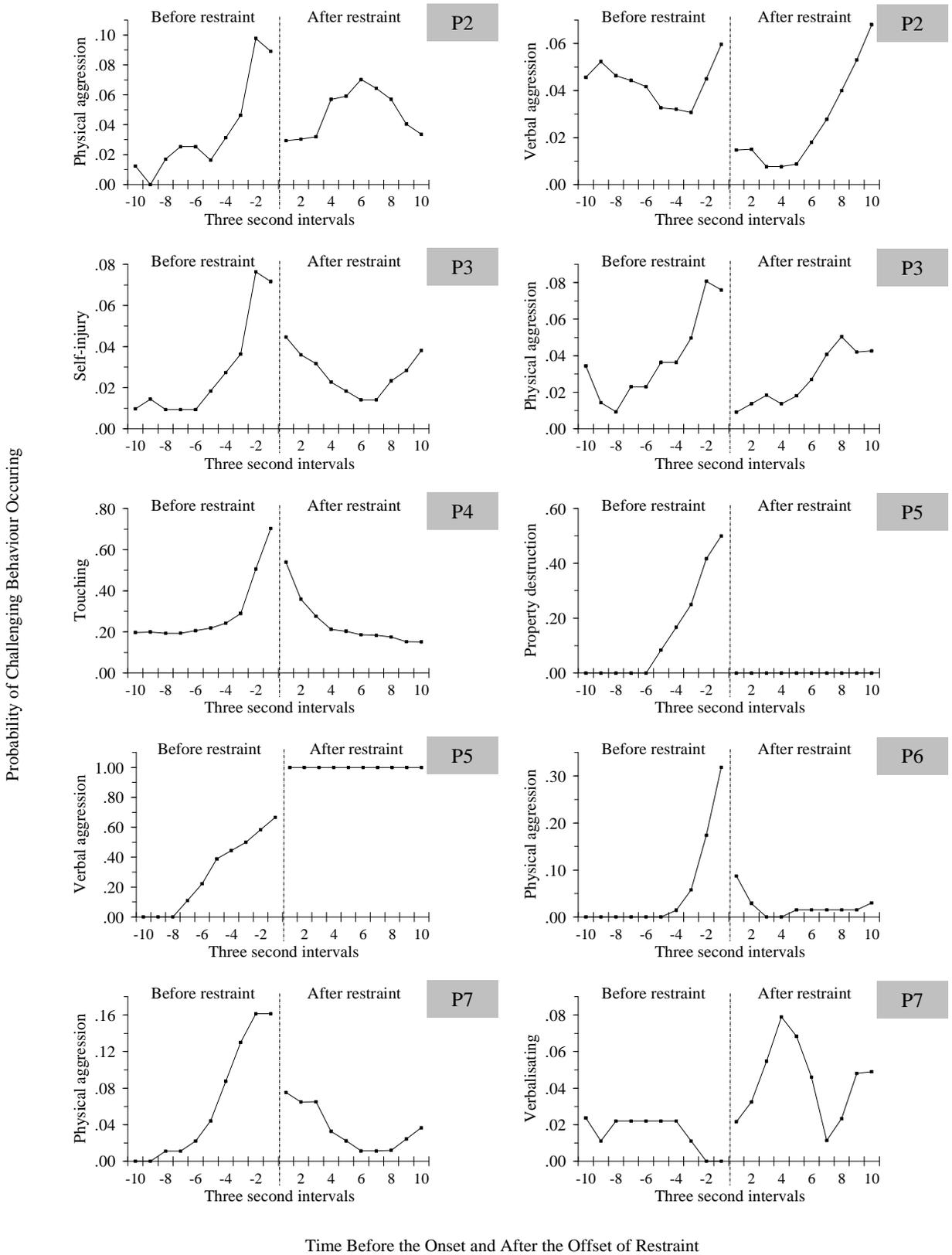


Figure 5.4 Probability of challenging behaviours occurring before and after restraint

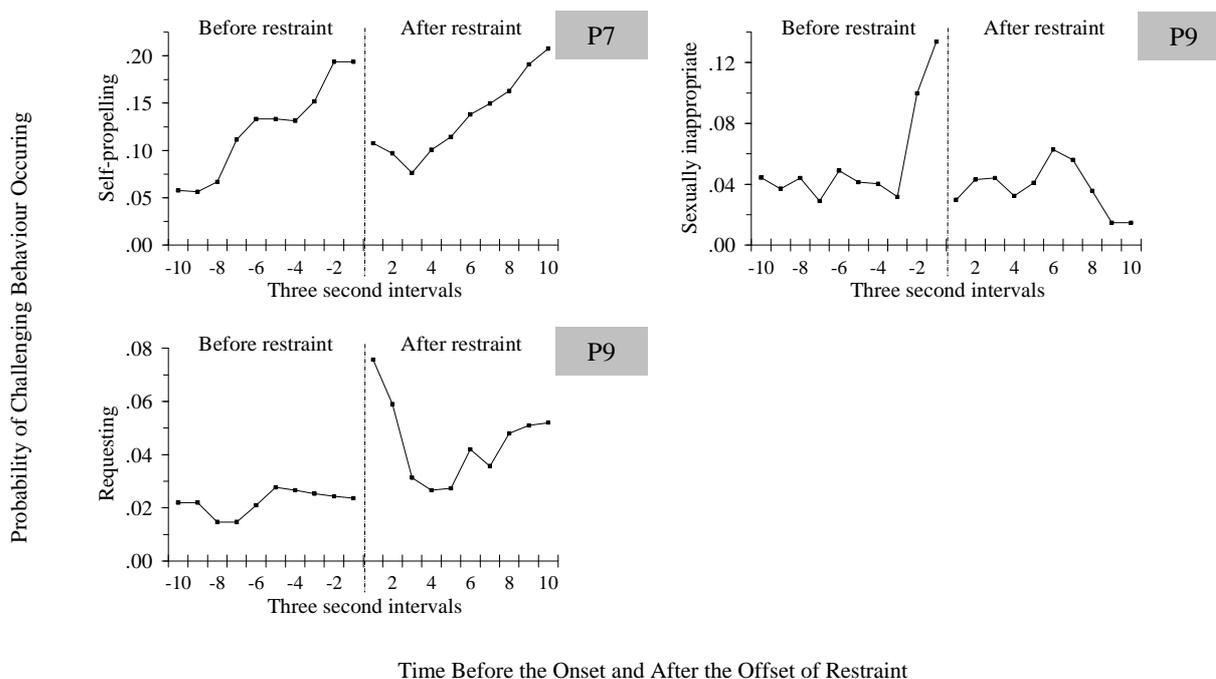


Figure 5.4 (cont.) Probability of challenging behaviours occurring before and after restraint

5.3.2.2 Management Programmes: Summary

The use of management programmes was examined for its effects on the target behaviour and other challenging behaviours. The likelihood of behaviours occurring in relation to restraint and during seclusion was investigated. A lag sequential analysis was used to calculate the probability of challenging behaviours occurring before the onset and after the offset of restraint. A descriptive account of the frequency of behaviours during periods of seclusion, in comparison to all other times, was also provided.

Weak support was found that indicated that the effectiveness in the short term of such programmed clinical responses was mixed. The target behaviour was successfully controlled with no further responses being emitted in less than a third of the cases only. In all other situations collateral increases in additional to challenging behaviours were noted, and sometimes without even a reduction in the target behaviour. The use of time-out procedures further increased the extent to which challenging behaviours were presented, in the short term. The proportion of behaviours occurring during periods of seclusion was greatly disproportionate compared to their usual rates.

For two participants, the implementation of their management programme caused a chain of events that became increasingly worse. One participant was restrained for a problematic behaviour that resulted in more serious acts of aggression. This in turn led to further restraint and hence more acts of physical aggression, and so on. The other participant underwent protective holding upon acts of self-injury. This restraining was met with physical

aggression, for which the participant was placed in seclusion. Then while in seclusion the participant engaged in unabated self-injury without impediment.

5.3.3 *Conclusions*

The strength of the findings in this study was mixed. The functional assessment was carried out using descriptive analysis methodologies. The relationship between challenging behaviours and environmental events was established first by concurrent analysis. Sequential analysis was then applied to ascertain whether support for these associations were evident. As covered in Chapter 4, the validity of the findings was upheld by dismissing any results that were explicitly contradicted by the sequential analysis. Lag sequential analysis was conducted also to investigate the relationships between challenging behaviours. Finally, a descriptive summary of the effects of management programmes on challenging behaviours was provided. The value of this study relates to its clinical value. The information derived from this study is relevant in clinical settings and provides an understand about the function of challenging behaviour, the relationship between different types and forms of behaviour, and the short-term effect of management programmes.

To conclude the study, separate summaries are provided for each participant. The analysis thus far has been at the level of the behaviour. To conclude, a synthesis of the data at the participant level will summarise the clinical implications. A concluding chronicle was created for all the findings that emerged in each case study. The conclusions were drawn from all the investigations regardless of empirical robustness. All findings were represented except those explicitly contradicted by sequential analysis. Such concluding chronicles are valued in a clinical setting. The collective information provided an opportunity to inspect patterns of exhibited behaviour and consider behaviour modification accordingly. The concluding chronicles also offered the information necessary to examine the programmes and intervention policies undertaken in hospital. A key to the symbols used in the concluding chronicle is presented in Figure 5.5. The concluding chronicles for each participant are then presenting, running from Figure 5.6 to Figure 5.14.

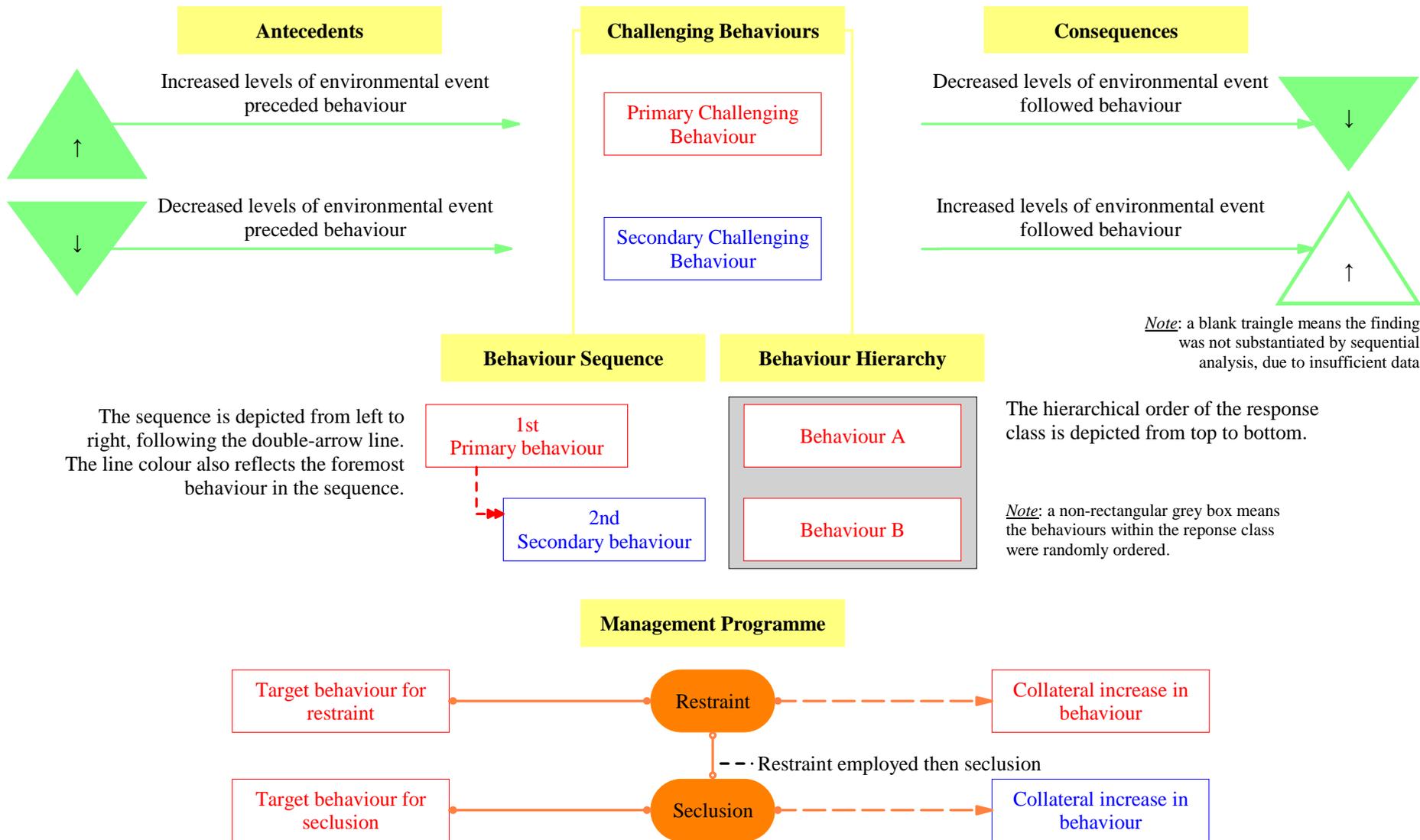


Figure 5.5 Concluding chronicles: Key

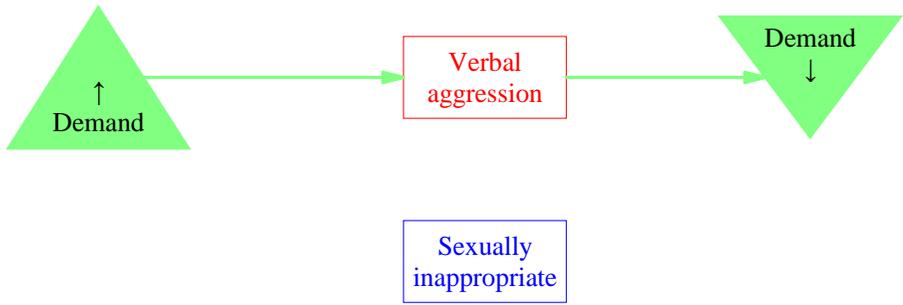


Figure 5.6 Concluding chronicle for participant 1

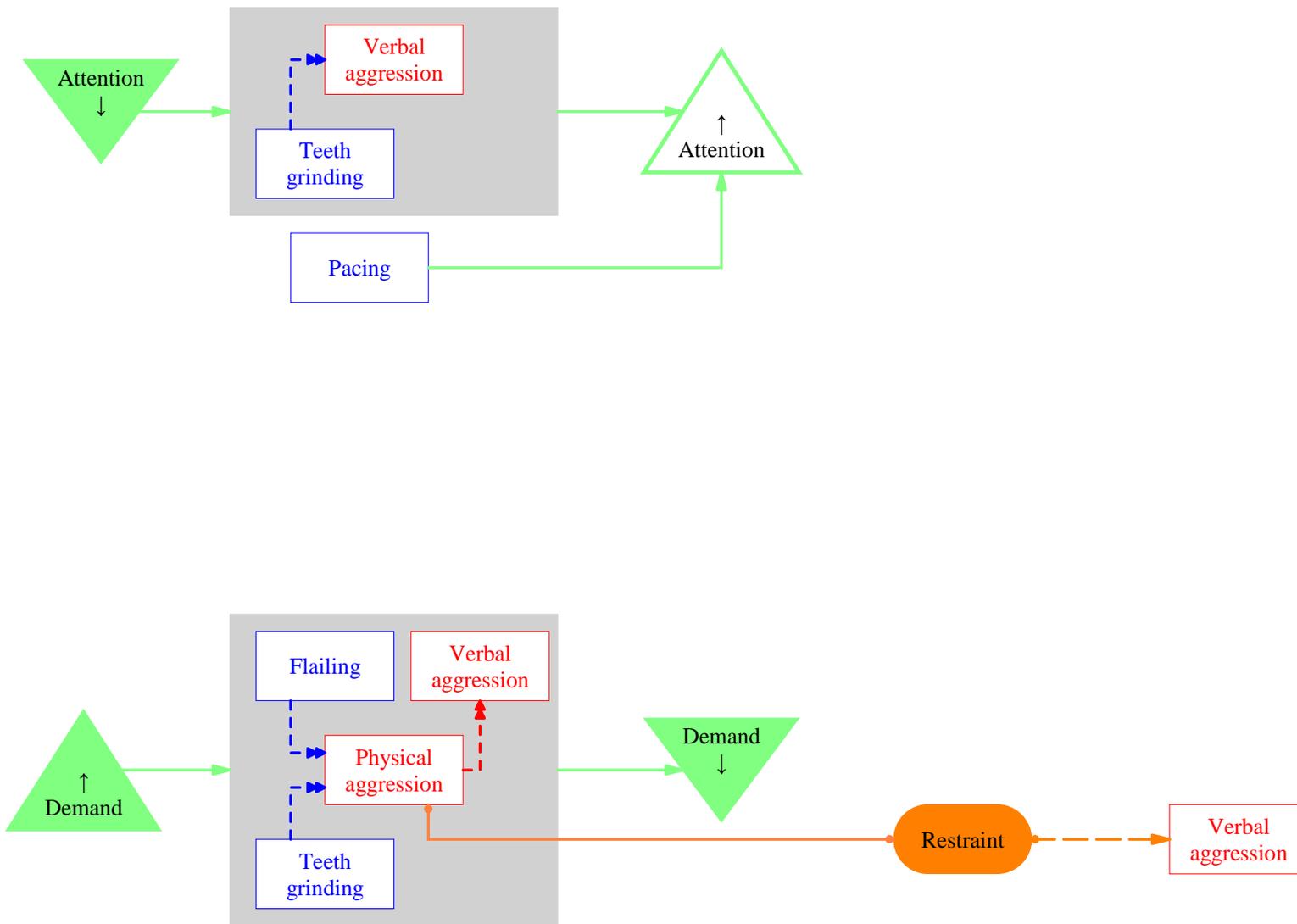


Figure 5.7 Concluding chronicle for participant 2

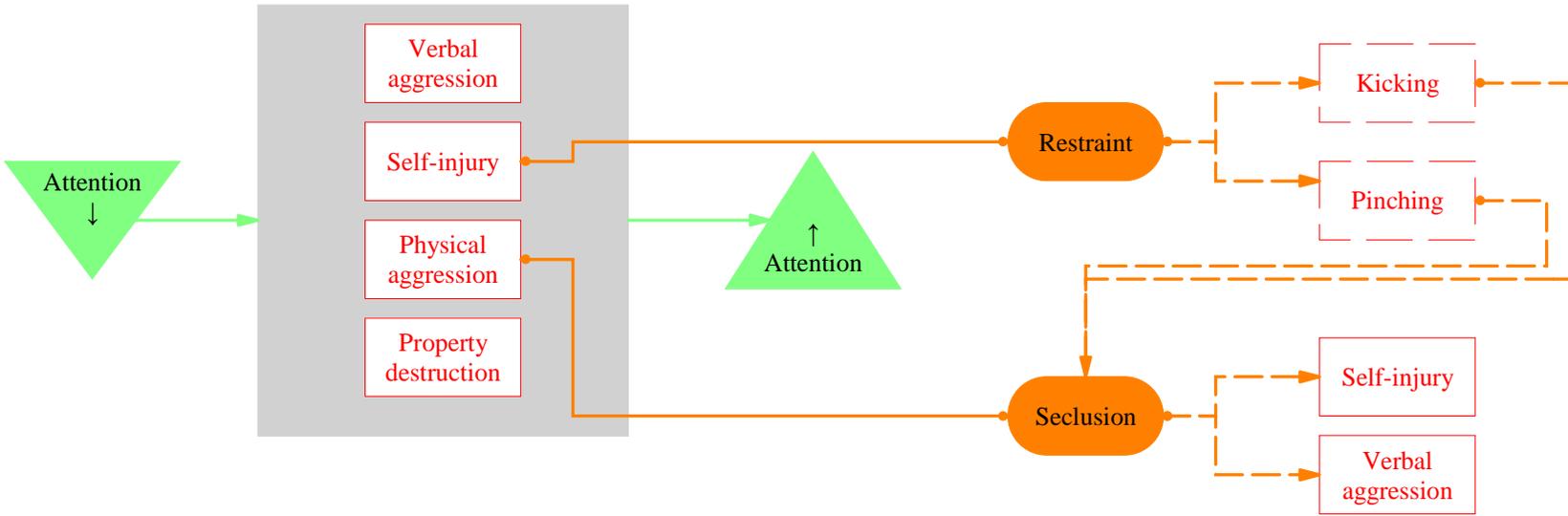


Figure 5.8 Concluding chronicle for participant 3

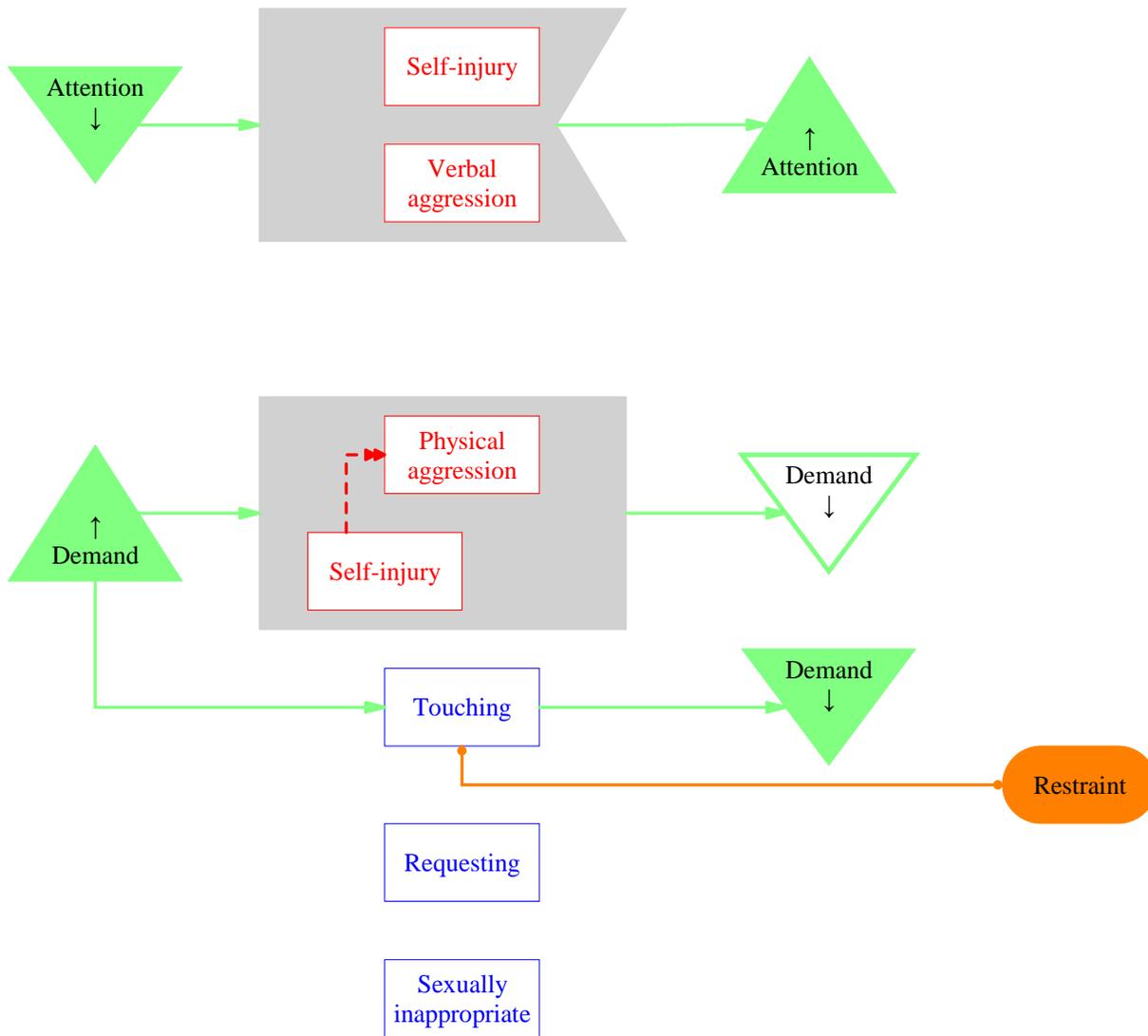


Figure 5.9 Concluding chronicle for participant 4

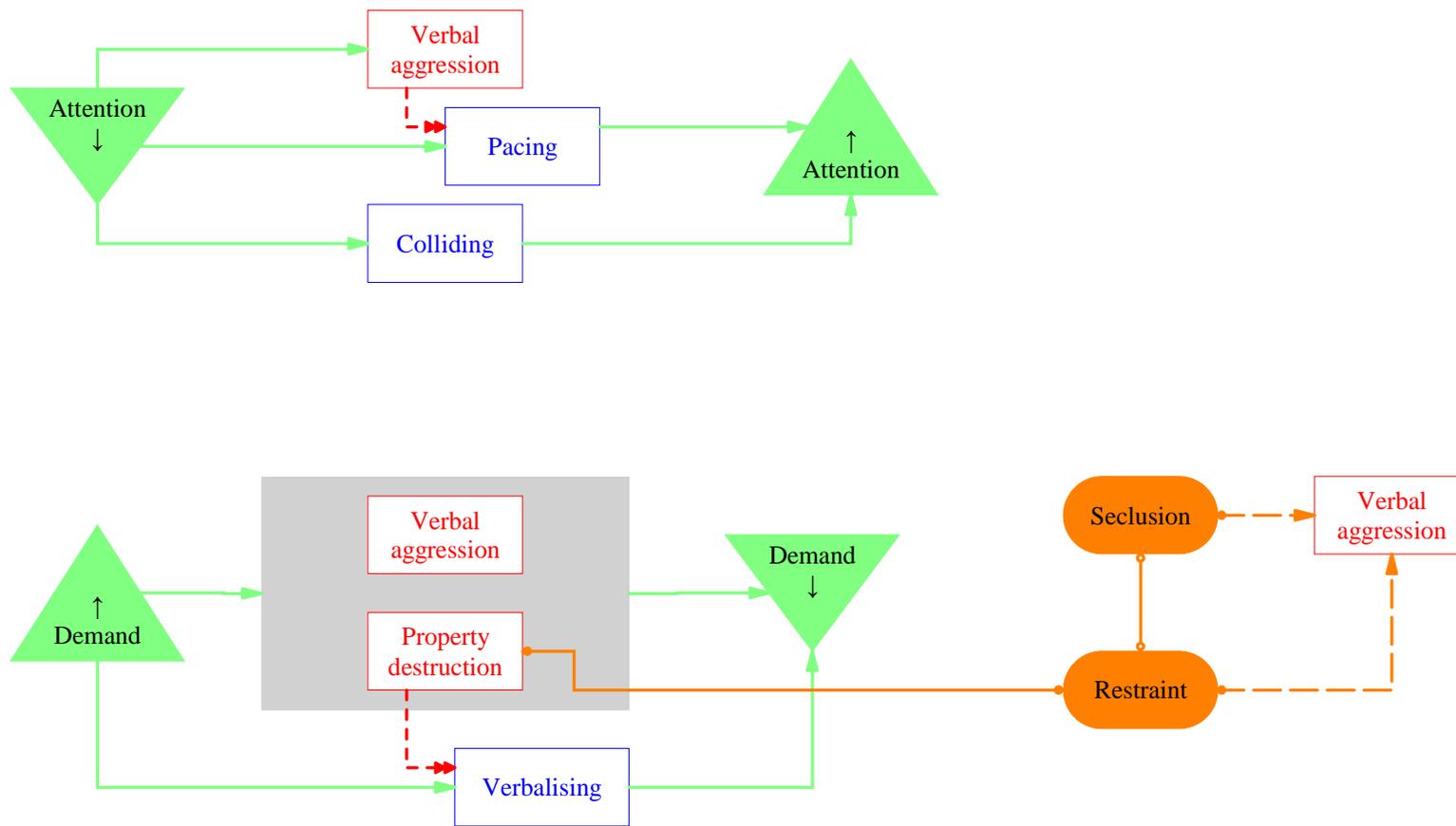


Figure 5.10 Concluding chronicle for participant 5

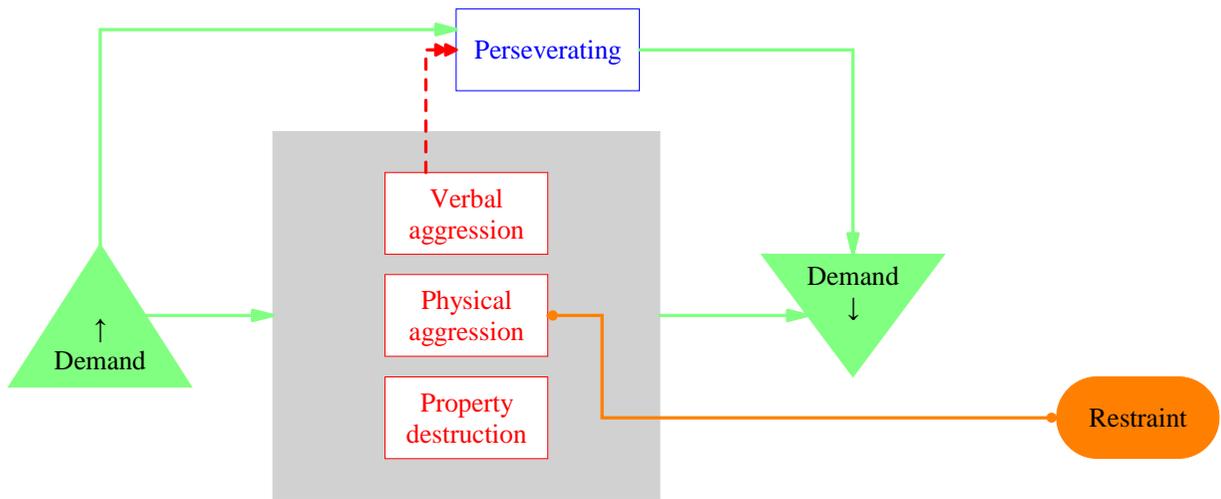


Figure 5.11 Concluding chronicle for participant 6

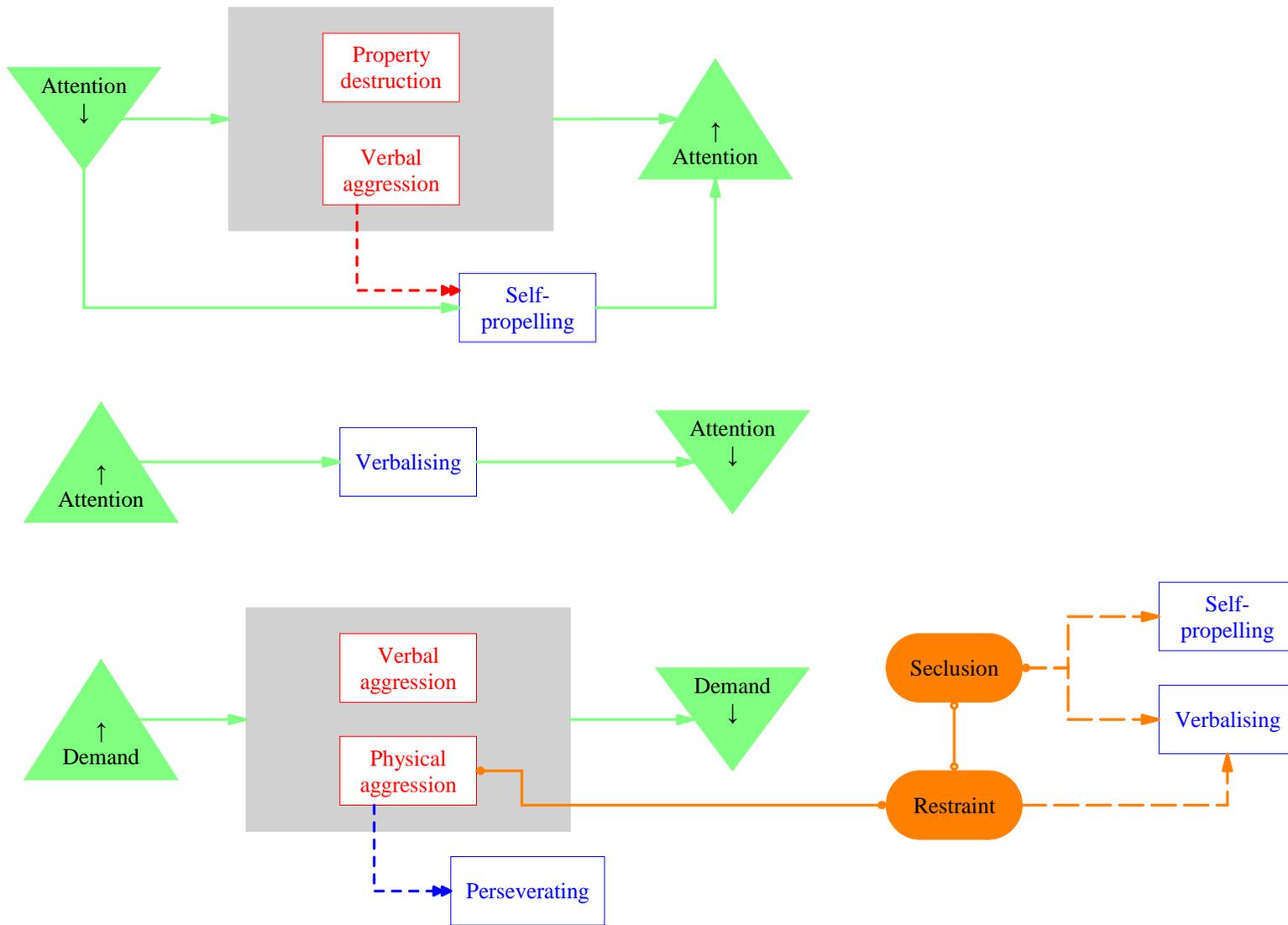


Figure 5.12 Concluding chronicle for participant 7

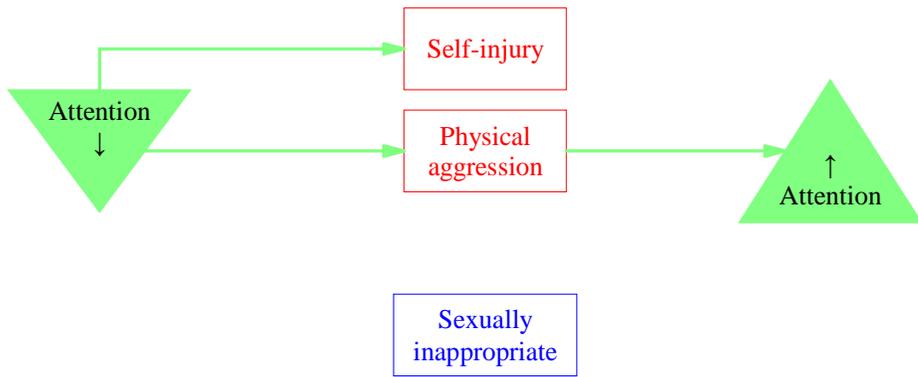


Figure 5.13 Concluding chronicle for participant 8

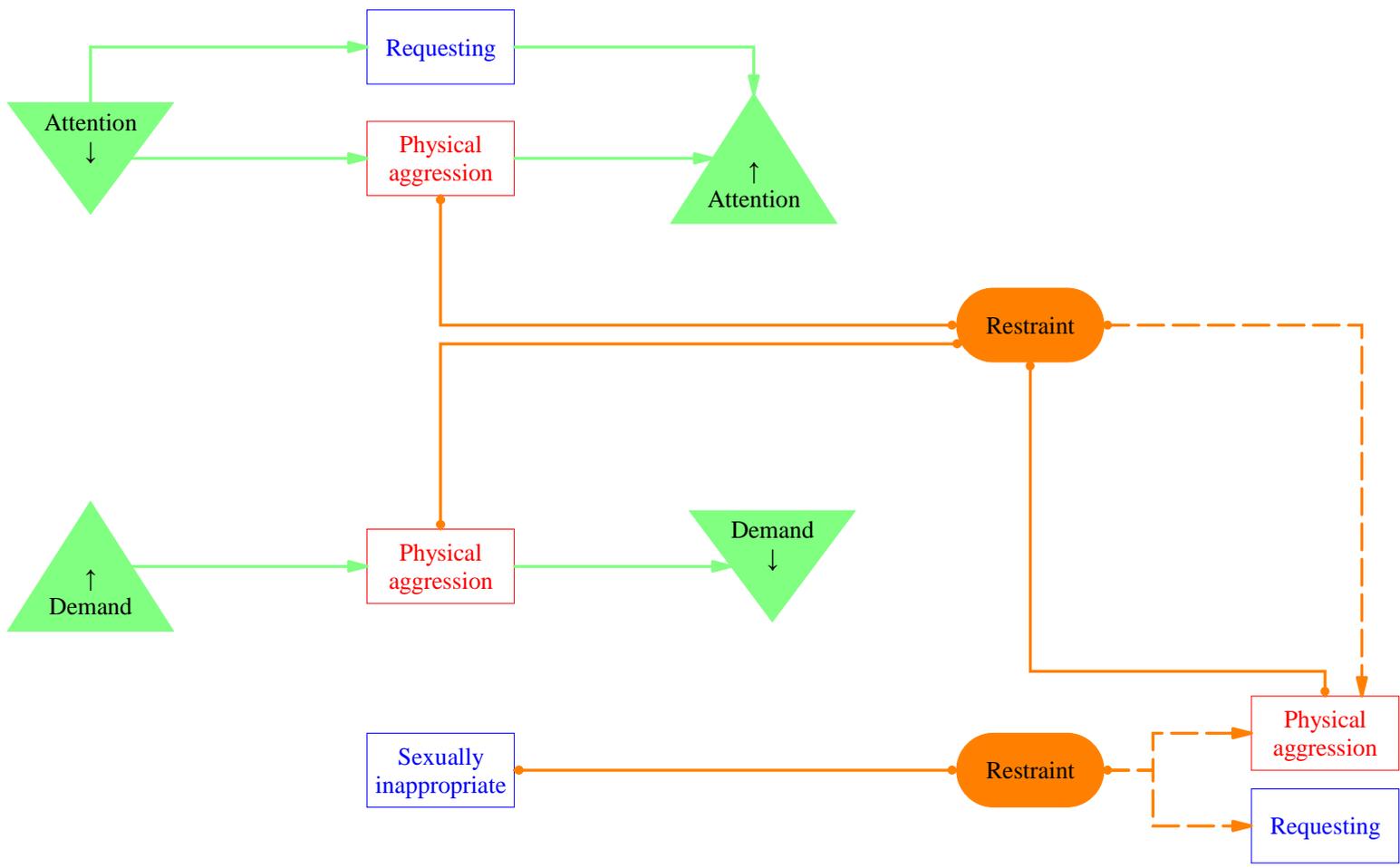


Figure 5.14 Concluding chronicle for participant 9

5.4 DISCUSSION

Behavioural analysis techniques applied previously, in Chapter 4, established functional relationships between challenging behaviours and environmental stimuli for all nine participants. The first study was designed to examine the organisation of these challenging behaviours. Various relationships between participant behaviours were investigated. The occurrences of the behaviours were explored to see if they were structured. It was found that organised structure existed for some functionally equivalent behaviours. The second study sought to examine antecedents to the use of management procedures and the immediate consequences to these events. The findings suggested some ineffective aspects to seclusion and time-out programmes in the short-term.

The first study examined the nature of any relationships between challenging behaviours. As shown in the results in section 4.3, some challenging behaviours were found to be members of the same response class. Despite being dissimilar in terms of topography, these behaviours demonstrated identical relationships with environmental events. Six participants presented separate challenging behaviours that were maintained by the same reinforcer. The complete behavioural repertoire of one participant was composed of challenging behaviours that all served the same function. These behaviours were considered to belong to the same response class and, therefore, to be functionally equivalent. This finding is consistent with other studies that have described multiple challenging behaviours as members of a single response class (Parrish, Cataldo, Kolko, Neef, & Egel, 1986; Cataldo, Ward, Russo, Riordan, & Bennett, 1986; Sprague & Horner, 1992).

The organisation of these response classes was investigated in this study, using a time-based lag sequential analysis. The investigation was developed on the principle that the occurrence probability of each response class member would be different, in spite of the behaviours having the same effect on the environment. The analysis involved comparing the conditional probabilities of the response class members at specific times in relation to the establishing operation. This investigated whether functionally equivalent challenging behaviours were either hierarchically ordered, sequentially structured or occurred randomly. There were five instances of a response class serving a demand escape function. In all cases, the conditional probability trends of the behaviours in relation to the onset of demand indicated that the response class was organised. A sequential pattern of responding emerged for the behaviours in the response class of participants 2 and 4. One interpretation of this sequence is that the offset of one behaviour served as the discriminative stimulus for the onset

of the next, thereby forming a response chain (Richman *et al.*, 1999; Smith & Churchill, 2002). For participants 5, 6, and 7, the response class members were hierarchically ordered. At all times the conditional probabilities of all topographies were distinct (Evans *et al.*, 1988; Scotti *et al.*, 1991a). Three response classes were maintained by social attention. In these cases, the conditional probabilities were calculated in the thirty second periods before and after the offset of attention. An organised structure emerged for some of these response classes. A hierarchical structure was found for the response classes exhibited by participants 3 and 7. A random pattern only emerged for participant 4. So, all the findings, except one, support the prediction that functionally equivalent challenging behaviours were organised in some way (Lalli *et al.*, 1995).

The existence of response classes that are organised in a structured manner has significant theoretical and clinical implications. According to the matching theory account, response allocation is determined by response effort, rate and quality of reinforcement and the immediacy of reinforcement (Horner *et al.*, 1990; Neef *et al.*, 1992, 1993). Consequently, the elimination of challenging behaviours can be sought by altering any or all of these parameters. The conceptualisation of hierarchically ordered response classes, then, is that the sequence of topographies is determined by the history of punishment associated with each response. Consequently, the response class behaviours to occur foremost are those that are less effortful, less likely to be punished and more likely to be reinforced promptly and consistently (Smith & Churchill, 2002). Research has shown that more severe forms of challenging behaviour in a hierarchically ordered response class are not exhibited because the less severe forms are commonly reinforced and seldom punished (Richman *et al.*, 1999). The results of the present study also concurred with this notion. *Verbal aggression* was the most likely class member to be exhibited at all times within all demand contingent response classes. *Verbal aggression* was also found to be foremost in all hierarchical response classes maintained by social attention. These persistent findings relate to the likely presumption that the response effort associated with verbal aggression is low (Lalli *et al.*, 1995). This conceptualisation of hierarchical response classes influences the clinical application of extinction procedures. The application of extinction procedures to the foremost challenging behaviours of a hierarchy is likely to result in an increased occurrence rate of the subsequent response members. This occurs due to the fact that extinction procedures alter the response efficiency of the target behaviour. The succeeding response choice then is a more aversive challenging behaviour. The more aversive response has a greater probability of reinforcement despite being increasingly effortful. In fact, it is actually because the succeeding response is more aversive that it is more likely to evoke a reinforcing outcome (Oliver, 1995). As such, extinction

procedures applied inappropriately may lead to an escalation of progressively severe challenging behaviours. The descriptive analyses conducted in this study provides a systematic procedure for identifying the structure of response classes, which brings great benefit when designing intervention strategies, especially those based on extinction.

A distinguishing feature of the study was the separate descriptive analyses conducted for both primary and secondary challenging behaviours. These challenging behaviour types, respectively, related to directed acts of aggression and problematic conduct. The association between both types of challenging behaviours was examined. It was predicted that functionally equivalent behaviour types would be temporally related to each other. The temporal relationship between functionally equivalent primary and secondary challenging behaviours was investigated using a time-based lag sequential analysis. The conditional probability of the secondary challenging behaviour occurring in relation to the primary challenging behaviour was calculated. Again, functional equivalence was determined by the results of the descriptive analyses, as presented in section 4.3. A potential threat to the validity arose in three cases where interpretations of function were not supported explicitly by the sequential analysis. In these cases, where insufficient data prevented the analysis, the findings of the concurrent analysis were assumed to be accurate. Moreover, no standardised criterion of significance was applied in the analysis, which is a limitation of the present study. Only the relative differences in the trends of probability occurrences were considered. Only those cases with meaningful patterns were presented, which were subjectively determined. No interrelationship between behaviour types with identical maintaining processes emerged in six instances. There were a few cases where the secondary challenging behaviours acted as precursors to the primary challenging behaviour. For participant 2, *teeth grinding* and *flailing* preceded some primary challenging behaviours. In most cases the secondary challenging behaviour followed the occurrence of the primary challenging behaviour. The likelihood of four secondary challenging behaviours, exhibited by participants 5, 6 and 7, showed an increased trend after the onset of the corresponding primary challenging behaviours.

The descriptive analysis conducted in this study has enabled a full assessment of response classes and their common reinforcing contingencies. This has led to the discovery of precursor behaviours. The identification of precursor behaviours has potentially considerable benefits in the treatment of challenging behaviour. The potential lies in the possibility of treating less aversive behaviours as a way of eliminating more severe challenging behaviours. This can happen if a response class contains both non-aggressive and aggressive challenging behaviours and the former typically precedes the later. In this way, it is conceivable that if heavy contingencies are placed on benign behaviours, which occur

earlier in the response hierarchy or chain, then the probability of more severe challenging behaviours occurring would be reduced by default. The application of this procedure would require the implementation of interventions based on functional equivalence training (Carr *et al.*, 1985; Durand, 1990; 1999). The goal would be to teach brain injury survivors to use adaptive (communicative) responses that are functionally equivalent to the challenging behaviours they seek to replace. In this way, alternative and more efficient responses can be learnt that supersede benign challenging behaviours. Consequently, if brain injury survivors have the means to achieve the same function served by the precursor response then the need to engage in subsequent, more severe challenging behaviours is automatically removed. The findings of the study suggest that such an intervention strategy could have been implemented with participant 2, who engaged in secondary challenging behaviours in advance of primary challenging behaviours. The *teeth grinding* exhibited by participant 2 preceded *verbal aggression* and also *flailing* and *teeth grinding* served as precursors behaviours to *physical aggression* (which in turn preceded *verbal aggression*). The descriptive analysis methodology provides an invaluable technique to identify those topographies to target for functional communication training, as well as those more severe topographies that will be phased out as a direct consequence.

The second study sought to investigate the short-term effects of different management procedures on the immediate behaviours on the brain injured participants. The study investigated the consequences of protective holding (restraint) and time-out procedures (seclusion). Clinical interventions are not often conceptualised strictly as an environmental event. However since such programmed interventions are contingent on participant behaviour they can be conceptualised as environmental stimuli. Occurring in response to predetermined target behaviours, management procedures are environmental stimuli that serve as either a reinforcer or punisher. A time-based lag sequential analysis was conducted to examine the effect of restraint on the targeted behaviour and also on other participant behaviours. The conditional probability of behaviours occurring in the thirty second period before the onset of restraint and in the thirty second period after the offset of restraint was calculated. An account of the frequencies and percentages of behaviours occurring during seclusion was also provided. All nine participants were subject to restraint and/or seclusion as part of their clinical programme. The analysis was not conducted for two participants because the frequency and extent of the restrictive procedures used was minimal. Restraint procedures were fully effective for participant 4 only. In this case, restraint successfully reduced the target behaviour and produced no incidental behaviours as a consequence. The targeted behaviours of participants 5, 6, 7 and 9 were successfully reduced in the short term by

restraint but collateral increases in aggression were documented. These participants demonstrated contingent increases in both primary and secondary challenging behaviours. In all other cases the ineffectiveness of restraint was twofold, in that it failed to reduce the target behaviour and also led to undesirable indirect effects. For instance, participant 3 exhibited particular behaviours only when being restrained. Overall, the effectiveness of restraint as a programmed response, in reducing the target behaviour and not engendering incidental behaviours, is mixed. In the large majority of cases, it was found that restraint led to additional challenging behaviours. These outcomes of the study support others that have also reported punishment elicited aggression (Bitgood, Crowe, Suarez, & Peters, 1980; Johnson, Baumeister, Penland, & Inwald, 1982; Hagopian & Adelinis, 2001). A descriptive account of behaviours occurring during seclusion periods also showed the existence of collateral effects. An exclusionary or non-exclusionary time out procedure was applied to three participants. In all cases elevated levels of challenging behaviours were exhibited during the punishment period. For instance, on average, each participant spent 61% of the time-out duration engaged in *verbal aggression*. Other collateral behaviours were also shown to increase. Generally a significant proportion of behaviours, including the targeted behaviours and indirect behaviours, occurred during periods of restraint and seclusion.

All the findings of the descriptive analysis study, presented in Chapter 4, and this secondary analysis study were summarised at an individual level. A synthesis of the results for each participant was presented in the form of a concluding chronicle. Each chronicle provided a pictorial depiction of the exhibited primary and secondary challenging behaviours, and their antecedents and consequences. Challenging behaviours that served a function were also shown, along with an indication as to whether the function ascribed was substantiated by a sequential analysis. The chronicles also documented the existence of any response classes and highlighted those that were ordered, either sequentially or hierarchically. The behavioural chain of events surrounding management programmes was also shown. The concluding chronicles are of great clinical value. The information provides the means to inspect response patterns and their interrelationships. Such a graphic representation has the practical advantage of facilitating different aspects of behaviour modification. A multidisciplinary rehabilitative approach may consider individual facets of the delineation provided by the chronicles. So, for instance, clinicians may choose to implement positive behaviour supports, alter the consequences or revise existing management strategies. Such approaches may be adopted either in isolation or in combination. Furthermore, the chronicles could be updated to chart the progress of the neurorehabilitation process and serve as a management appraisal tool.

CHAPTER 6 STRUCTURED DESCRIPTIVE ASSESSMENTS

6.1 INTRODUCTION

The arguments for functional assessments, outlined in section 2.1, shall be summarised briefly here. An accurate assessment of behavioural function is required to enhance the effectiveness of behavioural interventions. Such functional assessments should be conducted prior to implementing any behavioural intervention. An intervention that is devised without knowledge of the target behaviour's function may inadvertently reinforce that challenging behaviour or simply be less effective. A functional assessment offers a rationale on which to base a behavioural intervention and provides some assurance of its clinical success. Various strategies can be used to conduct functional assessments, as described in section 2.2. There are two broad approaches to conducting functional assessments; direct and indirect approaches. Indirect methods of functional assessment involve gathering data from an informant, using questionnaires or rating scales. Indirect methods can be conducted in a small amount of time and provide a wide range of information. However the reliability and validity of such methods have been questioned. Direct methods of functional assessment relate to descriptive assessments and experimental functional analysis. Both direct methods have associated strengths and weaknesses.

Descriptive assessments involve observing challenging behaviours and their associated environmental events under naturalistic conditions. However, the method can be time-intensive. A large amount of time may be required to reveal maintaining variables, especially if target behaviours are infrequently reinforced. Indeed, the relevant stimuli may be undetectable if carers deliberately avoid specific contexts that occasion challenging behaviours (Taylor & Carr, 1993). The main disadvantage relates to the correlational nature of the information yielded as the method only identifies associations between challenging behaviour and social stimuli. In contrast, experimental functional analyses tests whether challenging behaviours are directly affected by various antecedent conditions and consequences. The method involves the systematic manipulation of environmental variables in an artificial setting. The main limitation is its poor ecological validity given that the imposed analogue conditions may not represent contingencies operating in the natural environment. In essence, the greater degree of control exerted in experimental functional analyses is both an advantage and disadvantage. The benefit that functional relations can be tested and verified has the associated cost of poor ecological validity.

As described in section 2.2.5, structured descriptive assessments reconcile the conceptual and practical limitations of descriptive and experimental functional analyses. The procedure of a structured descriptive assessment integrates the methodology of both approaches. This hybrid approach has two defining features. The first feature is that it involves the systematic presentation of different classes of antecedent events shown to evoke challenging behaviour, which resembles the rationale of experimental functional analyses. However, unlike the experimental model, consequences are not manipulated and so naturally occurring responses are recorded (Freeman, Anderson, & Scotti, 2000). The second feature, which is typical of all descriptive analytical assessments, is that it is conducted in the natural environment by participants' typical care providers. This further contrasts with experimental designs that are conducted in artificial settings by experimenters.

The behavioural functions derived from structured descriptive assessments have been shown to be congruent with experimental functional analytical methods (Anderson & Long, 2002; English & Anderson, 2006). The treatment utility of the technology has also been supported by studies that have tested the effectiveness of interventions derived from it (Anderson *et al.*, 2002; Anderson, English, & Hedrick, 2006; English *et al.*, 2006). The external validity of structured descriptive assessments has been further supported by the application of the procedure and subsequent implementation of effective interventions with a typically developing population (Anderson *et al.*, 2006). Another significant advantage of the method relates to its efficiency. It has been shown that the methodology is far more efficient than other more time-intensive unstructured descriptive analyses.

To date, the brain injury literature has not included published studies that have utilised this method of functional assessment. The purpose of this novel study was to conduct a structured descriptive assessment with traumatic brain injury survivors. The aim was to explore whether the assessment could be used to identify functional relationships of challenging behaviours exhibited by adult brain injury survivors. This was achieved by replicating most of the procedures already established for implementing a structured descriptive assessment (Freeman, Anderson, & Scotti, 2000; Anderson *et al.*, 2002; Anderson *et al.*, 2006; English *et al.*, 2006). One disparity, which is a weakness of this study, is that no other functional assessment methodology was used for comparison. The data analysis conducted in this study contrasts with others in terms of scrutiny. This study employed effect size measurements in order to more objectively measure differences in challenging behaviour rate across various antecedent conditions. The importance of effect size calculations in determining treatment outcome has been described previously in section 3.2.3. Also in this study conditional probability analyses were used to measure the likelihood of environmental

events occurring in response to the target. A detailed description of conditional probabilities and a rationale for using Yule's Q is offered in Appendix J.

6.2 METHOD

The study was conducted as part of service development at St Andrews.

6.2.1 Participants

6.2.1.1 Selection and Recruitment

Participants were selected by the Lead Psychologists at the hospital. Participants who presented challenging behaviours and who had demonstrated little rehabilitative progress were selected to be included in the study.

6.2.1.2 Study Participants

Complete observational data were collected and analysed for four participants. Participant 3 was the only one to be detained under the Mental Health Act 1993. All participants resided in a locked facility of an acute ward. Personal details and information regarding brain injury are presented in Table 6.1. The time-specific information provided in the table was accurate on the first day the participant was observed.

The participants' functional abilities and their brain injury severity are presented in Table 6.2. The information on participants' abilities was derived from informal observations and not from standardised tests. The severity of brain injury was measured at the time of trauma, using one of two classification systems, as discussed in section 1.4.2. Severity measures were available for two participants only and the index reported was the Glasgow Coma Scale (GCS).

Table 6.1 Demographic and brain injury details

Participant	Sex	Occupation	Education Level	Age (yr, mth)	Time since Admission (yr, mth)	Time Since Injury (yr, mth)	Causes of Injury	Type of Injury
1	M	[Information unavailable, in electronic version.]	[Information unavailable, in electronic version.]	45, 9	0, 8	5, 3	Road traffic accident, pedestrian	–
2	M			60, 10	0, 6	2, 8	Road traffic accident	Bilateral frontal contusions, chronic subarachnoid haemorrhage
3	M			49, 7	1, 3	4, 2	Attempted suicide by hanging	Hypoxic anoxic brain damage
4	M			49, 4	3, 2	5, 3	Road traffic accident	Chronic subarachnoid haemorrhage, cerebral contusion in right front temporal region, mild hydrocephalus

Table 6.2 Injury severity and functional abilities

Participant	Severity Index	Understands Simple Sentences	Articulates Speech	Physically Mobile	Able to Self Care	Controls All Bodily Functions
1	3/15 (GCS)	✓	✓	–	–	–
2	6/15 (GCS)	✓	✓	✓	✓	–
3	n.a.	✓	✓	–	✓	✓
4	n.a.	✓	–	–	–	–

Key:

n.a. data not available

✓ participant has competence in that ability

– participant can not demonstrate that functional ability

6.2.2 Procedure**6.2.2.1 Coding Techniques**

Observational software was used to collect and analyse data. The software package used was ObsWin (Martin *et al.*, 2001). A Windows CE version of the program was run on a handheld personal computer, the Hewlett Packard Jornada 690. This permitted the real time and simultaneous recording of up to 46 mutually exclusive variables. All variables were recorded by depressing keys on the computer keyboard. Each key was assigned to a different variable. The keys were allotted using colour-coded labelled stickers.

The same coding scheme was used for all participants. So the layout of the keyboard was constant across all observations. The operational definitions of the recorded variables are detailed in section 6.2.3. A catch-all key was used to mark any coding errors or unexpected incidents. The details of any such events were dictated quietly into a voice recording device. The coding scheme was determined in advance. All events were coded as durational variables. The length of a duration variable spans multiple time intervals, with a distinct onset and offset time. It is recorded by depressing the key to mark its onset and then again to indicate its offset.

6.2.2.2 Observations

Short observations were conducted with all participants prior to any formal data collection. These preliminary observations were a preparatory exercise. The data collected were not included in the study. The activity was a practice for the real recordings. It enabled the observers to experience some of the behaviours and interactions beforehand. This allowed them to discuss and formalise their agreement on operational definitions. The pilot study also

served to eliminate participants' reactivity to the observations before any experimental data were collected.

In addition to the preliminary observations, other measures were taken to enhance the validity of the study data. The observers collected data as covertly as possible. They constantly repositioned themselves so as to stand in the most unobtrusive location, out of the direct view of the participant. Whenever possible, the observers tried to blend in with staff and other participants. Measures were taken also to minimise the reactivity of staff to the observations. They were repeatedly informed about the aims of the assessment and the variables being recorded. Their anonymity was often assured to them. Members of staff were instructed to interact normally with the participant and not to engage with the observers.

The details of the observation sessions conducted for each participant are presented in Table 6.3. Approximately nine-and-a-half hours of observational data were recorded for the study. The mean observation time for each participant was approximately two hours and twenty minutes. The number of observation sessions conducted with participants ranged between 20 and 28. The mean length of each session was nearly five-and-a-half minutes.

Table 6.3 Observation details

Participant	Total Time (hr, min)	Number of Observation Sessions	Average Duration of Observation Session (min, sec)
1	2, 37	20	7, 06
2	2, 01	23	5, 15
3	2, 50	28	6, 04
4	1, 58	20	5, 53
Mean	2, 18	22.75	5, 29
SD	0, 24	3.77	1, 25
Range	1, 58 / 2, 50	20 / 28	5, 15 / 7, 06

6.2.2.3 *Structured Descriptive Assessments*

A multielement design was adopted in this study, which consisted of four experimental conditions. The participants were repeatedly and randomly exposed to demand, attention, tangible and control conditions, as detailed below. All experimental conditions took place in naturalistic settings, within the usual therapeutic environments of the ward. The sessions occurred at times when there was an increased opportunity to present the antecedent events, relevant to each condition, in an authentic manner. All experimental conditions were conducted by the participants' typical caregivers, which included nurses, physiotherapists, occupational therapists and psychologists. Sometimes the same caregiver was involved in all sessions of a particular experimental condition.

The demand condition involved the presentation of demands as the antecedent. Demand condition sessions were conducted at times and in settings when the participant was likely to be subjected to high rates of instructions and be expected to complete therapy-related tasks. These included learning-related tasks, personal grooming activities, occupational therapy projects and physiotherapy exercises. Caregivers were instructed to use typical strategies in order to get the participant to complete a usual task. No instructions were given on how the caregiver should respond given the occurrence of challenging behaviours. If caregivers had not prompted the participant to complete a task for one-and-a-half minutes, in the absence of challenging behaviours or compliance, they were reminded to resume prompting.

The attention condition was designed to establish the establishing operation of attention withdrawal. At least two minutes of social interaction occurred directly prior to the testing session. Caregivers were instructed to engage with the participant in a typical manner. It was required that no demands or requests be placed upon the participant during this contact. Preferred tangible items were kept out of sight of the participant throughout. The session was initiated at the moment when attention was withdrawn by caregivers. The caregivers were asked to pretend to undertake another activity that did not involve the participant or interact with another participant. This role-play required that caregivers act as if they were unable to directly interact with the participant any longer. Caregivers were not instructed on how they should respond to any challenging behaviours. If caregivers interacted with the participant for longer than one-and-a-half consecutive minutes, in the absence of any challenging behaviours, they were prompted to return to the activity and resume with the withdrawal of attention. The attention condition sessions for participants 2 and 4 were conducted in the communal living area when caregivers were busy and the likelihood of attention delivery was low. The bedroom was the setting for the attention condition sessions for participants 1 and 3.

The tangible condition was implemented to gauge the effect of withdrawing preferred activities or tangible items. The participant was given access to a preferred activity or a tangible item for at least two minutes directly prior to the testing session. The session was initiated at the moment when the preferred stimulus was removed. The caregivers were asked to fabricate a reason for ending access to the preferred stimulus. It was required that no demands or requests be made during the session. Caregivers were told to act as they would normally in response to any challenging behaviours. If, in the absence of challenging behaviour, caregivers reinstated the preferred stimulus for longer than one-and-a-half consecutive minutes, they were prompted to remove the stimulus again and resume with the withdrawal of the preferred item. The tangible condition sessions were conducted during participants' room-leave time and involved the cessation of access to music, television or magazines. The same preferred stimulus for each participant was used in the sessions.

The control condition was designed to simulate an enriched environment. Control condition sessions were conducted during non-structured leisure times for all participants. During these times, the participants had given access to preferred activities and tangible items (board games, newspapers, magazines, music, television and snacks). The caregivers were instructed to socially interact with the participant in a typical manner. This contact was required to be non-instructional and so caregivers were asked not to make any demands or requests during this contact. Again, instructions were not given on how caregivers should respond to any challenging behaviours. If caregivers did not interact with the participant for longer than one-and-a-half consecutive minutes they were prompted to do so.

The duration of each experimental condition session varied between participants. The length of the session was decided beforehand and reflected the functional abilities of each participant. However, sessions were terminated prematurely if participants became too distressed and exhibited an unusually high rate of challenging behaviours. A minimum of twenty sessions were conducted, as each of the four experimental conditions were repeated five times. The structured descriptive assessments continued until response differentiation was clearly evident or stable responding occurred (i.e. the successive difference in the last three datum point was not greater than $\pm 15\%$).

6.2.3 *Observer Agreement and Response Definitions*

Interobserver agreement measures are shown below along with the operational definition of the corresponding behaviour.

6.2.3.1 *Interobserver Agreement*

A second observer collected data independently of the primary observer. The data collected by the second observer was not analysed as part of the assessment. It was used only to gauge agreement between the observers. The details of the observations conducted by the second observer are presented in Table 6.4. On average, the second observer collected data during 26.4% (range 19.9% to 29.8%) of the total observation time.

Table 6.4 Observation details: Second observer

Participant	Total Observation Time (min, sec)	Observation Time as a Proportion of the Total Time (%)
1	42, 19	29.8
2	34, 14	28.3
3	47, 03	27.7
4	23, 25	19.9
Mean	36, 45	26.4%
SD	10, 21	4.43%
Range	1405 / 2823	19.9 / 29.8

The agreement between the observers was measured using the Kappa (κ) coefficient (Cohen, 1960). A full description of different agreement indices and the rationale for using the Kappa coefficient is provided in Appendix E. The agreement measures were calculated on a three second interval-by-interval basis. Concordance was deemed by both observers recording the occurrence (and non-occurrence) of the same event within the same three second time window. This small tolerance level served to diminish the effect of dissimilarities in observers' reaction times (Murphy, 1987; Hall *et al.*, 1992; Repp *et al.*, 1994b; Emerson *et al.*, 1996). Agreement was calculated for multiple pairs of data files. These results were summed across the files to provide an overall Kappa index for each participant.

6.2.3.2 *Operational Definitions of Participant Behaviours*

The operational definitions and agreement coefficients of participant behaviours are presented in Table 6.5. The target behaviour for participants 1, 2 and 4 was *aggression*. The

aggression variable was a collective code that incorporated various types of aggressive behaviours. *Aggression* comprised of physical aggression, verbal aggression and/or property destruction. Physical aggression was defined as an attempted or successful physical assault directed at another person, regardless of whether it may or may not have caused an actual bodily injury. This included acts of grabbing, hitting, kicking, pinching or punching. Verbal aggression was defined as a vocal outburst (of words or noise) that is shouted, or any speech containing swearing, or an insult or threat directed at another person. Property destruction was defined as a forceful act directed at an inanimate object, without necessarily breaking or marking it. The target behaviour for participant 3 was *perseverating*. The participant demonstrated no episodes of aggression, according to his records. *Perseverating* was defined as a repetitive recitation of a phrase, word or indecipherable verbalisation with little or no pause between each recitation. Participant 3 often made highly frequent requests for tangible items or preferred activities, such as ‘Can I have a cigarette please?’, ‘Can I go for a walk, please?’ or ‘Can I go to my room, please?’. The second participant behaviour that was recorded for all participants was *compliance*. The *compliance* variable was coded when the participant attempted to complete a task or request, following a prompt or instruction given by staff members.

Table 6.5 Operational definitions and Kappa values of participant behaviours

Participant Behaviour	Operational Definition		1	2	3	4
Aggression	Any act relating to physical aggression, property destruction and/or verbal aggression; such as attempted or successful physical assaults directed at another person, forceful acts directed at inanimate objects, vocal outbursts, insulting or threatening speech.	Onset	.57	.62	–	.99
		Presence	.72	.71	–	.99
Perseverating	Repeatedly reciting a phrase, word or indecipherable verbalisation with little or no pause between each recitation.	Onset	–	–	.70	–
		Presence	–	–	.87	–
Compliance	Attempting to complete a task or request, following a prompt or instruction given by staff members.	Onset	.50	.63	.49	.80
		Presence	.97	.91	.85	.91

6.2.3.3 *Operational Definitions of Staff Behaviours*

The coding scheme for staff behaviours was fixed. The same responses were recorded consistently across all observations. The coded variables related to the experimental conditions of the structured descriptive, namely attention, demand and tangible. They can be viewed as opposite pairs each pertaining to one of these dimensions. The staff behaviours were: *demand / escape delivery* and *attention delivery / attention removal* and *tangible delivery / tangible removal*. The operational definitions and agreement coefficients of staff behaviours are presented in Table 6.6. The staff behaviour *escape delivery* continued until the participant engaged in *compliance* or until a further *demand* was made by staff. The variable code *attention deprivation*, which marked the absence of *attention delivery*, remained until *attention delivery* was resumed or a *demand* was given. *Tangible removal* continued to be coded until the preferred activity or tangible item was reintroduced.

Table 6.6 Operational definitions and Kappa values of staff behaviours

Staff Behaviour	Operational Definition		1	2	3	4
Demand	Offering a verbal or physical prompt to instruct the participant to act or complete a task, as part of an ongoing instructional context.	Onset	.53	.74	.62	.57
		Presence	.98	.94	.91	.94
Escape Delivery	Allowing the participant to not comply with the prompts given.	Onset	.53	.99	.44	.57
		Presence	.98	.99	.78	.77
Attention Delivery	Engaging in social, non-care related interaction with the participant, using either verbal or physical techniques, such as touching, asking questions, giving praise or making verbal statements.	Onset	.78	.56	.46	.50
		Presence	.96	.91	.90	.93
Attention Deprivation	Ceasing to engage in non-instructional, social contact with the participant.	Onset	.80	.77	.55	.87
		Presence	.97	.95	.78	.99
Tangible Delivery	Allowing the participant access to a preferred activity or tangible item, by either presenting the stimulus or permitting the participant to independently obtain it.	Onset	.80	.99	.99	.99
		Presence	.99	.99	.99	.99
Tangible Removal	Disallowing the participant (further) access to a preferred activity or tangible item by removing the stimulus or blocking access to it.	Onset	.75	.99	.50	.00
		Presence	.99	.99	.99	.00

6.2.4 *Data Analysis*

The data were analysed in three phases. The preliminary analysis concerned the procedural integrity of the structured descriptive assessments for each participant. The next analysis assessed the rate of challenging behaviour in each experiment condition. The last phase related to the likelihood of consequent events following challenging behaviour.

The procedural integrity of the structured descriptive assessments was assessed. This was done by measuring the extent to which separate antecedent events occurred in each experimental condition. The number of intervals that *attention deprivation*, *demand* and *tangible removal* occurred in each condition was presented as a proportion of the total time. This calculation was conducted for each participant.

The occurrence rate of challenging behaviour was calculated in each experimental condition session. The percentage of intervals in which challenging behaviour occurred across all experimental conditions was calculated for each participant. In addition, effect size measurements were also calculated. These provided an objective index of the differences in occurrence between experimental conditions and the control condition. A nonparametric measure was utilised in order to calculate effect size from only a small number of data points (Kraemer *et al.*, 1982). The delta statistic (δ) (Cliff, 1993; 1996), which was used in this study, related the probability that individual scores in one group (the experimental group) are likely to be greater than scores in the other group (the control group). A detailed description of the delta statistic and its merits has been provided in section 3.2.3.

The likelihood of consequent events following challenging behaviour was assessed using sequential analysis techniques. A time-based sequential analysis model was used to determine the temporal associations between challenging behaviour and environmental events (Emerson *et al.*, 1995; Emerson *et al.*, 1996; Forman *et al.*, 2002; Millichap *et al.*, 2003). The conditional probability of *attention delivery*, *escape delivery* and *tangible delivery* occurring given an episode of challenging behaviour was calculated. The analysis parameters were a ten-second time frame and the onset of both independent and dependent variables. The analysis pertained to the question; given the onset of challenging behaviour, what is the likelihood of an environmental event beginning within ten seconds? The conditional probability was calculated for each experimental condition separately and for all assessment conditions collectively. These measures were compared against the corresponding unconditional probabilities. The unconditional probability calculation related the likelihood of *attention delivery*, *escape delivery* and *tangible delivery* occurring in any case, irrespective of challenging behaviour happening.

An additional measure was used that assessed the degree of association between challenging behaviour and environmental events. This measurement was the Yule's Q index, which provided a correlational statistic of association (see, Hall *et al.*, 1997; Oliver *et al.*, 1999). The Yule's Q measure presented a standardised version of the odds ratio. A comprehensive description of conditional probabilities and the rationale for using Yule's Q is provided in Appendix J. A Yule's Q integer greater than or equal to 0.5 was taken to indicate a significant co-occurrence between the challenging behaviour and the environmental event. This represented a level of association three times greater than that expected by chance. A Yule's Q value greater than or equal to 0.8 corresponded to a level of association five times greater than that expected by chance.

The results of the data analysis were deciphered to establish a credible behavioural function, where appropriate. The stimulus preceding the challenging behaviour was determined by considering the rate of challenging behaviour across the experimental conditions and the extent of antecedent events in those conditions. Ascertaining the environment events that occasioned challenging behaviour was the first step in detecting behavioural function. Additional support was needed to show the challenging behaviour was subject to a process of socially mediated reinforcement. This was resolved by considering the likelihood of consequent events following the occurrence of challenging behaviour. In this way, the findings were conceptualised in terms of positive social reinforcement, positive reinforcement of tangible items, negative reinforcement in the form of demand escape or negative reinforcement in the form of social escape.

6.3 RESULTS

The results of the structured descriptive assessments are presented in this section. The summary statistics for all participants are presented in section 6.3.1. Thereafter the results for each participant are dealt with separately, in sections 6.3.2, 6.3.3, 6.3.4 and 6.3.5. Within each section, quantitative results are depicted on pages 224, 226, 228 and 230, for participants 1, 2, 3 and 4, respectively. The format of the results page is the same for all participants. Each results page includes two figures and a table, which relate to the three phases of the data analysis (see section 6.2.4). The first figure contains a bar chart that depicts the proportion of antecedent events that occurred across experimental conditions. The second figure is a line graph that shows the occurrence rate of challenging behaviour in each experimental condition. The table relates the conditional probabilities of environmental events occurring after challenging behaviour.

6.3.1 Summary Statistics

The summary statistics of participant behaviours are presented in Table 6.7. The mean duration of an episode of challenging behaviour ranged from 2.5 seconds (participant 1) to 4.9 seconds (participant 2). The frequency was greatest for participant 3 who exhibited 161 episodes of perseveration per hour. The lowest rate was 53 episodes of challenging behaviour presented by participant 4.

Table 6.7 Summary statistics of participant behaviours

Participant	Target Behaviour	Proportion of Total Time (%)	Mean Duration (sec)	Median Duration (sec)	Frequency Onset	
					Total	Per Hour
1	Aggression	8.16	2.53	2	275	116
	Compliance	15.29	17.86	6	73	31
2	Aggression	13.03	4.91	4	193	96
	Compliance	14.31	9.19	7	113	56
3	Perseverating	12.56	2.80	2	457	161
	Compliance	12.13	10.32	7	120	42
4	Aggression	4.43	2.99	3	104	53
	Compliance	16.29	9.13	7	126	64

6.3.2 Case Study: Participant 1

As shown in Figure 6.1, the extent to which relevant antecedent events occurred in each experimental condition was pertinent. The only antecedent event evidenced in the attention conditions was *attention deprivation*, which occurred 89% of the time. *Demand* and *attention deprivation* occurred in the demand condition in 74% and 6% of the intervals respectively. Two antecedent events were also recorded in the tangible condition. In addition to *tangible removal*, which occurred throughout (99%) the tangible condition, *attention deprivation* was found to have occurred for 64% of the time.

As depicted in Figure 6.2, low levels of challenging behaviour were recorded in two demand condition sessions and in one control condition session. So, the probability of challenging behaviour occurring in these conditions was negligible. Challenging behaviour occurred in all sessions of the attention and tangible conditions. Effect size calculations indicated that occurrence in both the attention condition ($\delta = 1.00$) and tangible condition ($\delta = .92$) was significantly greater than the control condition. However the likelihood of

occurrence in the attention condition (.10) was five times greater than in the tangible condition (.02).

These results suggest that challenging behaviour was occasioned by *attention deprivation*. The high levels of challenging behaviour exhibited in the attention conditions reflect the fact that *attention deprivation* was the only antecedent event to occur in the attention condition. The contention that *attention deprivation* was the antecedent to challenging behaviour may explain the low levels of responding recorded in the tangible conditions. As already noted, the tangible condition was made up of two antecedent events; *tangible removal* and *attention deprivation*. It is possible that the challenging behaviour exhibited in the tangible condition was in response to *attention deprivation*, as opposed to *tangible removal*.

The notion of challenging behaviour occurring in response to *attention deprivation* is further supported by the results that suggest that *attention delivery* was significantly likely to follow challenging behaviour. As related in Table 6.8, overall, across all attention conditions, the conditional probability of *attention delivery* given challenging behaviour was greater than its unconditional probability (.24 vs. .09). This finding was found in each experimental condition except for the demand condition. Furthermore, the association between challenging behaviour and consequent *attention delivery* was significant in the attention condition (Yule's $Q = .57$) and tangible condition (Yule's $Q = .72$).

PARTICIPANT 1

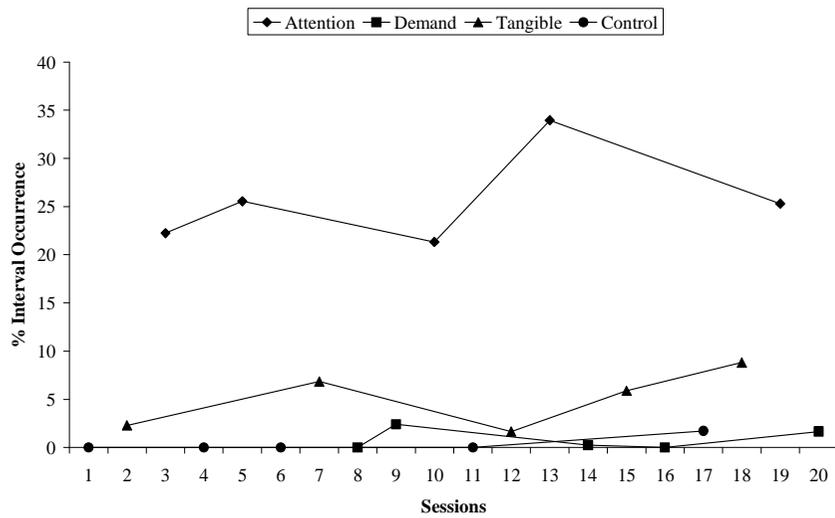


Figure 6.2 Occurrence of challenging behaviour in each experimental condition: Participant 1

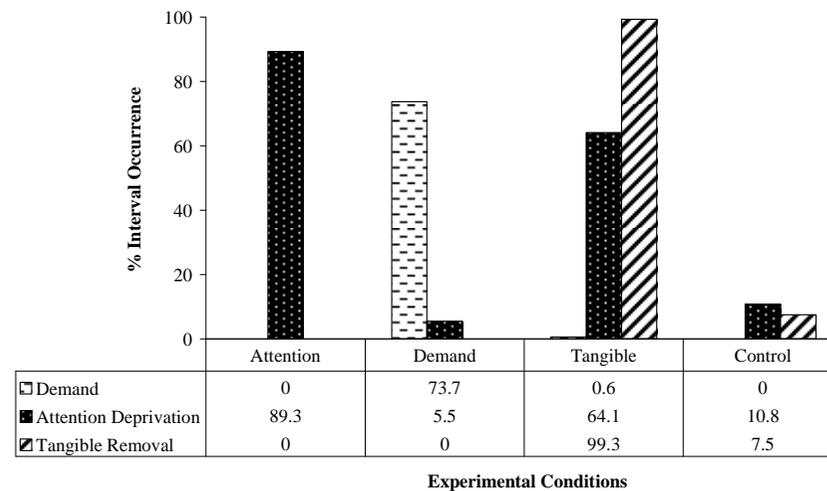


Figure 6.1 Total occurrence of antecedent events across experimental conditions: Participant 1

Table 6.8 The likelihood of consequent events occurring in different experimental conditions: Participant 1

Condition	Target Behaviour	Attention Delivery			Tangible Delivery			Escape Delivery		
	UCP	UCP	CP	Yule's Q	UCP	CP	Yule's Q	UCP	CP	Yule's Q
All	.032	.085	.240	.568	.002	.000	-1.00	.005	.015	.542
Attention	.102	.119	.212	.379	-	-	-	-	-	-
Demand	.004	.060	.000	-1.00	-	-	-	.019	.500	.967
Tangible	.019	.107	.410	.722	-	-	-	-	-	-
Control	.001	.057	.500	.888	.009	.000	-1.00	-	-	-

Key:
 UCP – The unconditional probability of occurrence.
 CP – The conditional probability of occurrence given the onset of challenging behaviour.

6.3.3 Case Study: Participant 2

As shown in Figure 6.3, the only antecedent event in the attention conditions was *attention deprivation*, which occurred 87% of the time. The demand and tangible conditions were predominantly made up of the relevant antecedent events, i.e. *demand* (64%) and *tangible removal* (98%). However, high levels of *attention deprivation* also occurred in these two conditions. Staff engaged in *attention deprivation* during 39% of intervals in the demand condition and 41% in the tangible condition.

As depicted in Figure 6.4, challenging behaviour occurred very infrequently in a small number of attention condition sessions, in one tangible condition session and in one control condition session. Consequently, near zero probabilities (range .001 to .007 [3dp]) of occurrence was recorded for challenging behaviour in these conditions. Challenging behaviour was presented in every session (7/7) of the demand condition. The likelihood of challenging behaviour occurring during all demand conditions was .05, which was markedly different to the other experimental conditions. Calculations of effect size confirmed these findings. Delta statistic values for the demand, tangible and attention conditions were $\delta = 1.00$, $\delta = .04$ and $\delta = .28$, respectively.

This finding suggests that challenging behaviour was occasioned by *demand*. The data supports the view that the establishing operation in the demand condition was *demand*, even though *attention deprivation* was present in over a third (39%) of the intervals. This is shown by the fact that challenging behaviour was not evoked by *attention deprivation* in the attention and tangible conditions.

The assumption that challenging behaviour served a demand escape function was qualified by the data in Table 6.9. The conditional probability of *escape delivery* following challenging behaviour (.25) was much greater than its unconditional probability (.11). Across all demand conditions, the association between challenging behaviour and consequent *escape delivery* was strong (Yule's $Q = .72$).

PARTICIPANT 2

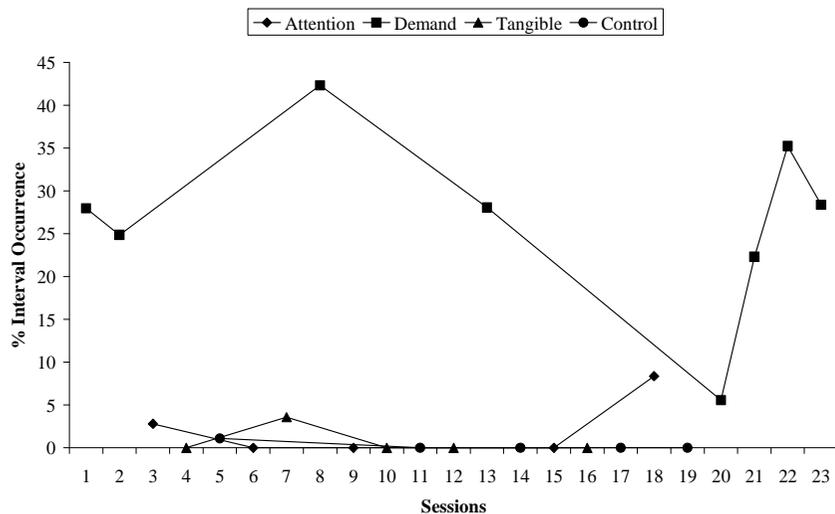


Figure 6.4 Occurrence of challenging behaviour in each experimental condition: Participant 2

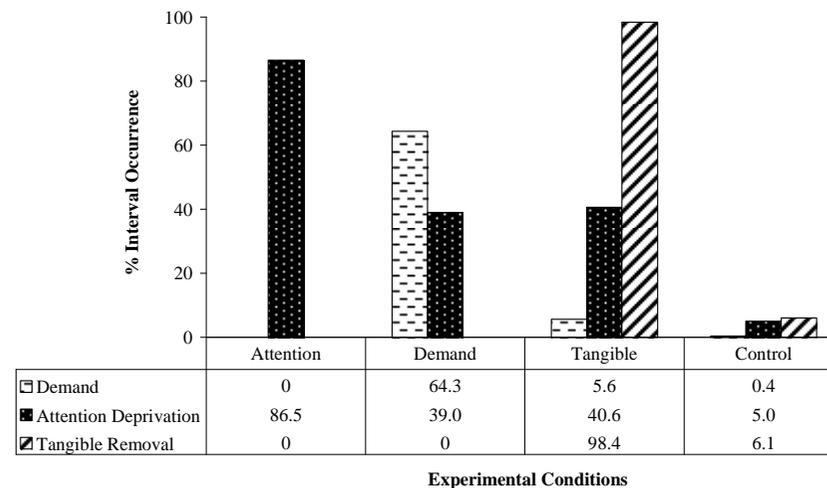


Figure 6.3 Total occurrence of antecedent events across the experimental conditions: Participant 2

Table 6.9 The likelihood of consequent events occurring in different experimental conditions: Participant 2

Condition	Target Behaviour	Attention Delivery			Tangible Delivery			Escape Delivery		
	UCP	UCP	CP	Yule's Q	UCP	CP	Yule's Q	UCP	CP	Yule's Q
All	.027	.086	.067	-.136	.004	.000	-1.00	.053	.233	.715
Attention	.007	.155	.500	.695	-	-	-	-	-	-
Demand	.054	.070	.044	-.246	-	-	-	.114	.250	.473
Tangible	.002	.131	.000	-1.00	.002	.000	-1.00	.005	.000	-1.00
Control	.001	.028	.000	-1.00	.018	.000	-1.00	-	-	-

Key:
 UCP – The unconditional probability of occurrence.
 CP – The conditional probability of occurrence given the onset of challenging behaviour.

6.3.4 Case Study: Participant 3

The extent to which relevant antecedent events occurred in each experimental condition was appropriate, as shown in Figure 6.5. The only antecedent event in the attention condition was *attention deprivation*, which occurred 84% of the time. *Demand* and *attention deprivation* occupied 60% and 5%, respectively, of the intervals in the demand condition. *Attention deprivation* also featured largely in the tangible condition (47%), in addition to the expected antecedent event of *tangible removal* (84%).

As depicted in Figure 6.6, the occurrence of challenging behaviour fluctuated across sessions of all experimental conditions. In terms of mean occurrence, however, distinct patterns emerged between the conditions. The unconditional probability of challenging behaviour occurring in the tangible, demand, attention and control condition was .08, .05, .04 and .01, respectively. Challenging behaviour was more likely to be exhibited in the tangible condition and thereafter, almost equally, in the demand and attention conditions. Measures of effect size confirmed these findings. A delta value (δ) of 1.0 was found for the tangible condition whereas the values for the demand and attention conditions were $\delta = .45$ and $\delta = .65$, respectively.

These findings do not make clear whether the establishing operation in the tangible condition was *tangible removal* or *attention deprivation*. As previously stated, both antecedent events occurred in the tangible condition. However, the data suggest more convincingly that *attention deprivation* occasioned challenging behaviour given the occurrence of challenging in the attention condition. As depicted in Table 6.10, challenging behaviour was consistently followed by *attention delivery*. This tends to suggest that the function of challenging behaviour was to gain social attention. The conditional probability of *attention delivery* given challenging behaviour was much greater than its unconditional probability in all experimental conditions. Moreover, the association between challenging behaviour and *attention delivery* was significant in the attention condition (Yule's $Q = .76$) and across all conditions collectively (Yule's $Q = .56$).

Challenging behaviour was also found to have occurred in demand conditions also. However, it would be difficult to claim a demand escape function because the data do not indicate that challenging behaviour was reinforced by *escape delivery*. The conditional probability of *escape delivery* in the demand condition was greater than its unconditional counterpart (.10 vs. .06) but this findings was weak (Yule's $Q = .27$).

PARTICIPANT 3

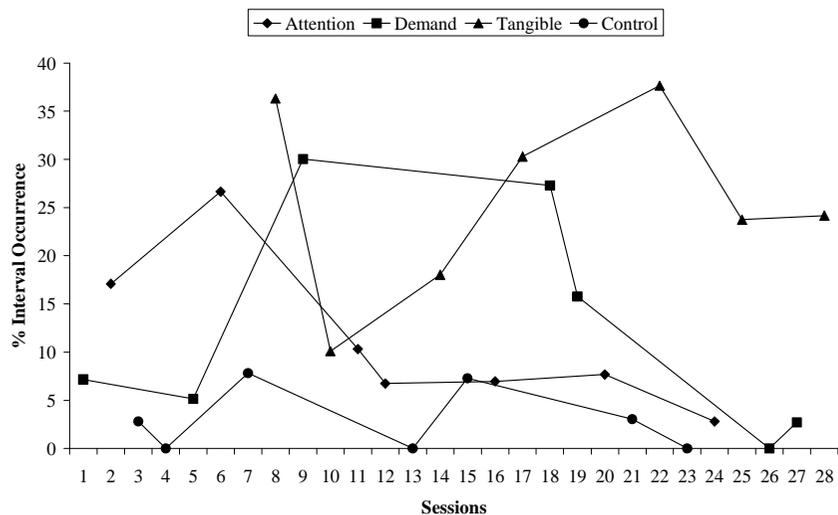


Figure 6.6 Occurrence of challenging behaviour in each experimental condition: Participant 3

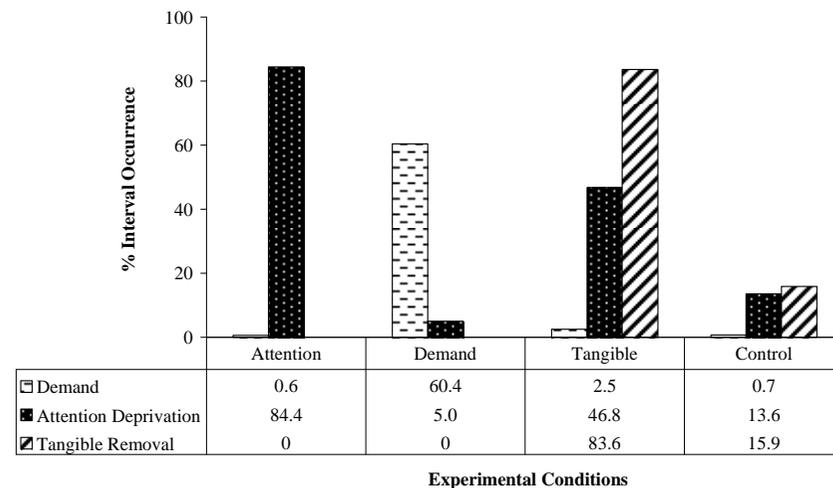


Figure 6.5 Total occurrence of antecedent events across the experimental conditions: Participant 3

Table 6.10 The likelihood of consequent events occurring in different experimental conditions: Participant 3

Condition	Target Behaviour	Attention Delivery			Tangible Delivery			Escape Delivery		
	UCP	UCP	CP	Yule's Q	UCP	CP	Yule's Q	UCP	CP	Yule's Q
All	.045	.087	.235	.559	.006	.002	-.472	.018	.031	.290
Attention	.038	.109	.442	.762	-	-	-	-	-	-
Demand	.049	.082	.196	.492	-	-	-	.063	.101	.272
Tangible	.083	.083	.172	.437	.012	.005	-.452	.002	.000	-1.00
Control	.012	.069	.25	.550	.013	.000	-1.00	-	-	-

Key:
 UCP – The unconditional probability of occurrence.
 CP – The conditional probability of occurrence given the onset of challenging behaviour.

6.3.5 Case Study: Participant 4

As shown in Figure 6.7, appropriate levels of antecedent events were found in the experimental conditions. The attention condition consisted predominantly of *attention delivery* (93%), with a small amount of *demand* (2%). The demand condition was made up of the appropriate antecedent event *demand* (59%). In addition, staff also engaged in *attention deprivation* during 15% of intervals in the demand condition.

As depicted in Figure 6.8, low rates of challenging behaviour were recorded in three tangible condition sessions and in four attention condition sessions. Consequently the unconditional probabilities of challenging behaviour in these conditions was .006 [3dp] and .005 [3dp], respectively. Every demand condition session (5/5) evidenced high levels of challenging behaviour. The probability of its occurrence was .04, which was markedly different to the other experimental conditions. The positive delta value found for the demand condition ($\delta = .92$) contrasted with negative values for the tangible condition ($\delta = -.36$) and attention condition ($\delta = -.40$).

This finding suggests that challenging behaviour was occasioned by *demand*. The data supports the view that the establishing operation in the demand condition was *demand*, even though *attention deprivation* was present in 15% of the intervals. This is shown by the fact that challenging behaviour did not respond to the levels of *attention deprivation* in the attention and tangible conditions.

The notion that challenging behaviour served a demand escape function was qualified by the data in Table 6.11. The conditional probability of *escape delivery* following challenging behaviour was much greater than its unconditional probability in all experimental conditions and across conditions collectively. The association between challenging behaviour and consequent *escape delivery* was significant in all cases, with Yule's Q values ranging from .59 to .97.

PARTICIPANT 4

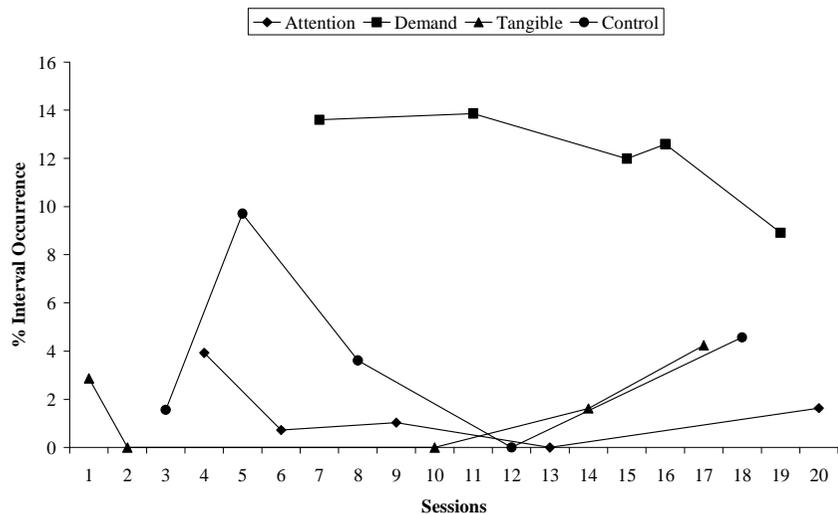


Figure 6.8 Occurrence of challenging behaviour in each experimental condition: Participant 4

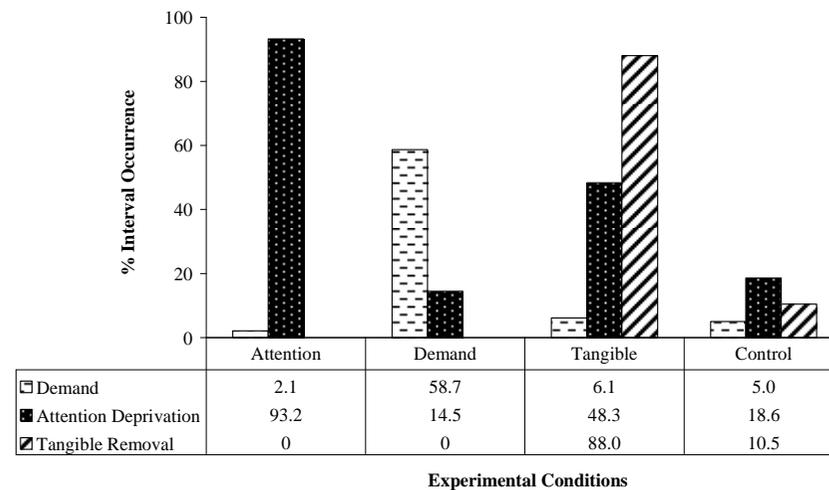


Figure 6.7 Total occurrence of antecedent events across the experimental conditions: Participant 4

Table 6.11 The likelihood of consequent events occurring in different experimental conditions: Participant 4

Condition	Target Behaviour	Attention Delivery			Tangible Delivery			Escape Delivery		
	UCP	UCP	CP	Yule's Q	UCP	CP	Yule's Q	UCP	CP	Yule's Q
All	.015	.155	.305	.416	.008	.000	-1.00	.020	.086	.662
Attention	.005	.044	.250	.765	-	-	-	.003	.125	.965
Demand	.039	.253	.462	.437	-	-	-	.034	.154	.682
Tangible	.006	.164	.313	.417	.015	.000	-1.00	.024	.078	.589
Control	.014	.111	.200	.338	.023	.000	-1.00	.010	.050	.683

Key:
 UCP – The unconditional probability of occurrence.
 CP – The conditional probability of occurrence given the onset of challenging behaviour.

6.4 DISCUSSION

Functional assessments were conducted with survivors of traumatic brain injury using a structured descriptive assessment. This study was the first to apply this methodology to the brain injury population. Moreover, the study improved on previous structured descriptive assessment studies by using effect size calculations and conditional probabilities in its analysis. The investigation explored the utility of the technique for identifying environmental events affecting challenging behaviours. The environment-behaviour relationships that emerged were examined to see whether they were congruent with a social reinforcement model. To this end, the aim of the study was to assess the effectiveness of structured descriptive assessments in generating hypotheses of behavioural function.

The findings suggested that structured descriptive techniques provided the means of successfully conducting functional assessments. Functional relations emerged from the assessment data of all four participants. The challenging behaviours exhibited by participants 1 and 4 were far more likely to occur under conditions characterised by the absence of attention. In addition, the likelihood of these behaviours being followed by attention delivery was five times greater than chance. Consequently the behaviours were deemed to serve an attention gaining function. The assessment results for participant 2 supported a demand escape hypothesis. It was found that challenging behaviour was occasioned by demand presentation and maintained by the removal of demands. The pattern of responding exhibited by participant 3 suggested that challenging behaviour occurred in response to the absence of attention and also to the presentation of demands. However, no reciprocal relationship emerged between the behaviour and demands. The likelihood of demand escape occurring in response to challenging behaviour was not great. However, the results did reveal significant associations between challenging behaviour and attention delivery consistently throughout all conditions. So it was determined that the challenging behaviour exhibited by participant 3 had established a social attention function.

The fundamental limitation of this study concerns the absence of convergent validity measures. The strength of the study's findings is limited without corroboration. The application of structured descriptive assessments in the brain injury population can only be evaluated fully by comparing the procedure with other functional assessments. Ideally future studies should implement experimental functional analyses for the purpose of confirmation. Alternatively, the validity of this study could have been determined by designing treatment programmes on the basis of its results. Future studies could measure the effectiveness of

structured descriptive techniques assessment by implementing treatments according to the behavioural functions derived from the assessment. Clinical data on the effectiveness of behavioural interventions for brain injury survivors based on the results of structured descriptive assessments are needed.

There are other limitations of structured descriptive assessments, in general. First, the method requires that antecedent conditions be presented at times and in settings when comparable antecedent events would have usually occurred. This procedure has the benefit of enhancing the ecological validity of the data. However it could be argued that the data may not generalise to different circumstances at other times and in other settings. Second, it may be claimed that the instructions given to caregivers to follow alters the natural environmental context and creates atypical interactions. Such criticism is far more relevant regarding experimental functional analyses. Nevertheless, it is true that the ecological validity of structured descriptive assessments is poor compared to unstructured descriptive methods. However, the benefits of exerting control over the presentation of antecedent events far outweigh the cost of losing a small degree of realism. This control enables functional assessments to be conducted efficiently in clinical settings without the need to wait for target environmental events and target behaviours to occur concurrently.

The assessments conducted in this study support continued efforts to incorporate a structured functional assessment approach within naturalistic settings. The findings have indicated that a formal descriptive methodology may be beneficial to practitioners in neurorehabilitation. The approach offers an efficient way of conducting clinical assessments of behavioural function. In this study the average total assessment duration for each participant was only 36 minutes. By investing only a short amount of time, the assessment generated hypotheses regarding function of challenging behaviour. This offers neurorehabilitation clinicians a truly productive technique for assessing new intakes of brain injury participants, in addition to reviewing behavioural function as part of an ongoing process. It may be the technique of choice for those who do not have the expertise and resources to design laboratory-based functional assessments or the time to conduct unstructured descriptive assessments.

CHAPTER 7 GENERAL DISCUSSION

As narrated in Chapter 1, traumatic brain injury is a pervasive and significant health issue, which has individual and societal implications. The distribution of the causes of traumatic brain injury varies according to age, sex and geographic location. Survivors of traumatic brain injury experience an array of problems. The consequences of traumatic brain injury encompass physical, cognitive and psychosocial impairments, as described in section 1.6. Generally, short-term recovery is associated with injury severity however long-term outcome is better predicted by an interaction of multiple variables. To improve the functioning skills of brain injury survivors, in order to enhance their chance of social reintegration, a multidisciplinary rehabilitation process, which is often intensive and lengthy, is required. The greatest single barrier to a successful therapeutic outcome is challenging behaviours. As covered in section 1.6.3.2, many survivors of traumatic brain injury exhibit various forms of challenging behaviours, which include physical aggression, property destruction, self-injury and verbal aggression. Other habitual and non-aggressive forms of challenging behaviours may also be exhibited.

Neurorehabilitation of challenging behaviours may involve the use of medication, cognitive remediation and/or behavioural modification techniques. As noted in section 1.7, these treatment models each have strengths and limitations. Consequently, a biopsychosocial model also exists that integrates medical, psychological and social models of treatment. This framework encompasses the complex interactions between biological, psychological and sociological factors of human functioning and presents a holistic alternative to unitary models. Pharmacological interventions succeed in suppressing challenging behaviours but only in the short-term, and may actually engender additional dysfunctional behaviours as a side-effect. The cognitive approach to therapy, which views cognitive impairments as the underpinning causes of challenging behaviours, is seemingly more effective. However, the cognitive approaches may be unsuitable for severely brain-injured survivors, whose cognitive limitations may be too great to be remediated by cognitive techniques and whose challenging behaviours may preclude them from participation in the first place. As proclaimed in section 1.7.3, interventions based on the behavioural model are suitable for all brain trauma survivors irrespective of the severity of their injury. Robust evidence exists to support the effectiveness of operant conditioning techniques in treating challenging behaviours and promoting functional skills.

The behavioural model posits that challenging behaviours are learned operant responses, which are precipitated by environmental stimuli and maintained by their

consequences. In this sense, challenging behaviours are seen as functional and, arguably, adaptive. So, in order for behavioural intervention techniques to be implemented effectively, the influence of the environment on the occurrence of challenging behaviours must be appraised beforehand. Learning-based interventions can then be designed according to the social contingencies that influence challenging behaviours. Otherwise, behavioural techniques that are implemented on an incorrect assumption of function may actually increase the occurrence rate of challenging behaviours. Consequently, as stated in section 2.2.1, the accurate identification of behavioural function is very important. An applied behaviour analytic approach to challenging behaviours seeks to demonstrate that changes in challenging behaviours are linked to social variables. This is done by measuring and analysing behaviours using functional behavioural assessments. The objective of functional assessment methods is to identify causal functional relationships between the challenging behaviours and environmental events. Once the behaviour function has been established then challenging behaviours can be modified, by teaching brain injury survivors to use alternative and more adaptive functionally equivalent responses, for example.

As described in section 2.2, various methods of functional assessments exist. Indirect functional assessments have a practical utility but provide data that has potentially questionable reliability and validity. As covered in section 2.2.3, descriptive analysis methods have high ecological validity but provide correlational data only. However, different types of descriptive analysis techniques exist, which vary according to the detail of output provided. Sequential analysis techniques are the most progressive kind of descriptive analysis. Sequential analyses assess how well past events predict future ones based on an analysis of probability. Sequential relationships between variables can be identified either by event- or time-based calculations. As such sequential analysis techniques were used in the empirical studies shown in Chapter 4 and Chapter 5, as discussed below. Experimental functional analyses involve the systematic manipulation of environmental variables, in order to identify those that control and maintain the target behaviour. Experimental control is demonstrated when a change in conditions brings an associated change in the target behaviour. The effects of stimulus conditions are measured precisely in a controlled environment and can be replicated. The empiricism of this methodology is its defining strength. Nevertheless, experimental approaches have numerous practical, conceptual and ethical limitations. First, they require a great deal of time, resources and expertise. Second, the analogue testing conditions may not represent the actual contingencies operating in the natural environment. Also, reinforcement processes are considered only in broad terms meaning that specific

reinforcers cannot be identified. Third, there are ethical implications associated with the purposeful presentation of stimuli that engender and maintain challenging behaviours.

The conceptual and practical limitations of descriptive and experimental functional analyses are to some extent reconciled in a structured descriptive assessment. This new technology, presented in section 2.2.5, is a hybrid that integrates aspects of the methodology from both approaches. Its first defining feature is that it involves the systematic presentation of different classes of antecedent events, which reflects the rationale of experimental functional analyses. However, unlike the experimental model, consequences are not manipulated and naturally occurring responses are allowed to happen instead. Its second defining feature is that it is conducted by caregivers in the natural environment, which resembles all descriptive analytical assessments. There is evidence to suggest that structured descriptive assessments enhance the outcome of behavioural interventions. As such, structured descriptive assessments provide an efficient and accurate way of conducting functional assessments of high clinical value. The empirical study presented in Chapter 6 has used a structured descriptive assessment to ascertain the function of challenging behaviours, as discussed below.

The first empirical study of this thesis, presented in Chapter 3, evaluates the effectiveness of behavioural interventions in treating challenging behaviours. A meta-analysis was conducted to investigate the treatment outcomes of studies that used behavioural interventions to treat challenging behaviours. This study was novel in a number of respects. It is the only meta-analytical study in the brain injury literature to focus solely on intervention strategies based on traditional behavioural procedures and to include only those studies that treated challenging behaviours. The present study also improved on other meta-analytical research by using effect size to quantify treatment outcome. With only one exception, all behavioural intervention studies were found to be effective in reducing challenging behaviours. These results suggest that interventions based on the behavioural model produce positive outcomes. However, as with all meta-analytical research, the study has a number of limitations relating to the publishing bias for positive outcomes and the lack of homogeneity in the reporting of outcome data. One important finding of this work was that behavioural interventional studies that used a pre-intervention functional assessment were no less effective than those that had not. This finding is incongruous with the premise of this thesis that functional assessments are a crucial aspect of behavioural interventions. However, the finding does not mean that functional assessments fail to enhance behavioural interventions. So, even though some behavioural interventions designed on the basis of clinical intuition determined

behavioural function correctly, it is still maintained that clinical intuition cannot supersede formal functional assessment procedures in the identification of behavioural function.

The overall findings of the meta-analysis study indicated that behavioural treatments were effective for the brain injury population. The effectiveness of learning-based models of intervention suggests that challenging behaviours exhibited by brain injury survivors may adhere to an operant model. The subsequent study sought to examine further this notion of challenging behaviours as operant responses through the application of an applied behaviour analytic approach. More specifically, the aim of the second empirical study, presented in Chapter 4, was to seek support for the view that challenging behaviours shown by brain injury survivors are environmentally dependent events, which influence and are influenced by social stimuli. This conceptualisation of challenging behaviours has been substantiated extensively in the intellectual disabilities field but far less so in the brain injury literature. A descriptive analysis was conducted to test whether challenging behaviours exhibited by survivors of traumatic brain injury were occasioned and/or maintained by social contingencies. The descriptive analyses carried out have advanced research in this area for a number of reasons. First, it has increased the small number of studies in the brain injury literature that have undertaken formal functional assessments. Second, a highly detailed level of analysis was conducted, which is unrivalled in the literature, by using observational software to collect and analyse descriptive data. Finally, the study focused on both aggressive and non-aggressive forms of challenging behaviours.

The study data were analysed using concurrent analyses and then sequential analyses, by way of verification. As presented in sections 4.3.2 and 4.3.3, the results of the concurrent analysis revealed that all aggressive challenging behaviours and all non-aggressive challenging behaviours, except for three cases of sexually inappropriate behaviours, were precipitated by at least one environmental event. All these challenging behaviours were ascribed function by using an algorithm that deciphered the results. The interpretations of function based on concurrent relationships were mostly substantiated by the results of the sequential analysis. Only 15% of significant concurrent analysis findings were not explicitly supported. It was also found that some challenging behaviours were preceded by multiple antecedents and were considered to server more than one function. This finding supports other studies in the applied behaviour analysis literature that have reported that multifunctional challenging behaviours exist. The results collectively promote the view that challenging behaviours are functional, orderly and predictable responses. They support the contention that challenging behaviours are socially mediated operants, which is congruent with the behavioural model, as described in section 1.7.3. The study extends other research in the brain

injury literature that has also discovered escape motivated challenging behaviours and attention motivated challenging behaviours.

The results of the study also indicated that the occurrence of both aggressive and non-aggressive challenging behaviours was influenced by environmental variables and in turn the presentation of environmental factors was influenced by challenging behaviours. The operant A-B-C model states that a challenging behaviour is occasioned by an aversive environmental event and is reinforced by the cessation of that event. The mutual reinforcement model builds on this by considering the caregiver and posits that the caregiver's behaviour is occasioned by an aversive challenging behaviour and is reinforced by the cessation of that challenging behaviour. The reciprocal and potentially incessant interrelationship between the behaviours of the patient and caregiver has important clinical implications. The fact challenging behaviours exhibited by survivors of traumatic brain injury adhered to a process of mutual reinforcement was a significant finding.

The descriptive analysis study also found evidence for the existence of multiple challenging behaviours with functional equivalence. As shown in the results in sections 4.3.1 and 4.3.2, some challenging behaviours, despite being dissimilar in terms of topography, demonstrated identical relationships with environmental events. Six participants presented separate challenging behaviours that were maintained by the same reinforcer. The complete behavioural repertoire of one participant was composed of challenging behaviours that all served the same function. Such behaviours are said to form one response class and, therefore, to be functionally equivalent. These findings are consistent with other studies that have described multiple challenging behaviours as members of a single response class. This discovery of behaviour repertoires occasioned by the same antecedent conditions and reinforced by the same consequences was the impetus for the subsequent study. Secondary analyses were conducted in the third empirical study in order to investigate further the organisation of such response classes. As presented in Chapter 5, this study analysed the same data set that was collected in the previous descriptive analysis study. One aim of the secondary analyses was to explore the organisation of challenging behaviours. The structure of response classes was analysed by using time-based sequential analyses, to compare the conditional probabilities of functionally equivalent challenging behaviours occurring in relation to the establishing operation. All five instances of a demand contingent response classes revealed conditional probability trends that suggested all class was organised. A sequential pattern of responding emerged for the behaviours in the response class of participants 2 and 4. One interpretation of this sequence is that the offset of one behaviour served as the discriminative stimulus for the onset of the next, thereby forming a response

chain (Richman *et al.*, 1999; Smith & Churchill, 2002). As shown in section 5.3.1.1, for three participants, the demand contingent response class members were all hierarchically ordered. A hierarchical structure was also found for the attention maintained response classes exhibited by another two participants. In summary, all the findings, except one, support the prediction that functionally equivalent challenging behaviours were organised in some way.

The findings that response classes were either hierarchically or sequentially structured have important clinical implications. According to the matching theory account, response class behaviours that occur first are those that are less effortful, less likely to be punished and more likely to be reinforced promptly and consistently, as determined by their historic associations. So, the response members of a hierarchically ordered response class that are emitted first are the less severe challenging behaviours. The more severe challenging behaviours are unlikely to be shown because the less severe forms are commonly reinforced and seldom punished. The results of the present study concurred with this notion. Verbal aggression was the most likely class member to be exhibited at all times within all demand contingent response classes. Verbal aggression was also found to be foremost in all hierarchical response classes maintained by social attention. This finding influences the clinical application of extinction procedures. The application of extinction procedures to the foremost challenging behaviours of a hierarchy is likely to result in an increased occurrence rate of the subsequent response members. Moreover, the succeeding response choice then is a more aversive challenging behaviour. As such, extinction procedures applied inappropriately may lead to an escalation of progressively severe challenging behaviours. The descriptive analyses conducted in this study provides a systematic procedure for identifying the structure of response classes, which brings great benefit when designing intervention strategies, especially those based on extinction.

The second aim of the secondary analysis study was to examine the use of management procedures, like restraint and seclusion. Again, sequential analysis techniques were used to unravel the chain of responses immediately surrounding the use of such techniques. The findings showed that in the short term, management procedures based on these techniques produced collateral increases in other challenging behaviours. In some cases, a set of mutually conflicting circumstances led to the almost-perpetual occurrence of challenging behaviour and restraint and/or seclusion. This information would prove to be of great value to clinical staff in their evaluation of management programmes. The graphic representation of the social contingencies maintaining the challenging behaviours of participants was provided. Again, this has benefit of summarising the theoretical work and providing information that has a high practical value.

Despite providing clinically relevant output, the descriptive analysis study and the secondary analysis study were not designed to be used as a clinical tool. However, it is possible that they could be used as such. Future research could replicate this study but without collecting such extensive observational data. Following on from this, the thesis concludes with the fourth empirical study, which used a functional assessment tool specifically for clinical rehabilitation settings. As presented in Chapter 6, the study used a structured descriptive assessment, as described in section 2.2.5, to ascertain the function of challenging behaviours. This novel study was the first to implement this new assessment protocol with the brain injury population. The work also improved on previous structured descriptive assessment studies by using conditional probabilities and effect size to assess the consequence of environmental events on challenging behaviours. An indirect assessment tool was also used to assess the convergent validity. The technique is more advantageous than natural observations as it exerts a degree of experimental control. However, as with any experimental design, the standard approach may not identify idiosyncratic contingencies. This limitation is not insurmountable but it requires additional assessments to be conducted. The findings of the study revealed functional relations for the challenging behaviours presented by all four participants. The challenging behaviours exhibited by two participants were far more likely to occur under conditions characterised by the absence of attention. The pattern of responding exhibited by the other two participants suggested that their challenging behaviour occurred in response to the absence of attention and hence served the function of gaining social attention function. The study showed that structured descriptive assessments were effective in generating hypotheses of behavioural function. However, the main limitation of the study concerns the absence of any corroborating evidence. This could have been determined by designing treatment programmes on the basis according to the behavioural functions derived from the assessment. Nevertheless, a structured functional assessment approach within naturalistic settings is highly beneficial in the field of neurorehabilitation. The approach offers an efficient way of conducting clinical assessments of behavioural function that can generate hypotheses regarding function of challenging behaviour. This offers clinicians a truly productive technique for assessing new intakes of brain injury participants, in addition to reviewing behavioural function as part of an ongoing process.

This thesis has provided strong support that challenging behaviours exhibited by survivors of traumatic brain injury are operant responses. It has evaluated published behavioural treatment studies and found them to be effective. It has also conducted a practical and efficient functional assessment procedure that is suitable for brain-injured adults. Future research that may follow up on this work should consider examining the link between

cognitive limitations, experienced by brain trauma survivors, and observed operant effects. Such research would be pioneering. It may be that particular cognitive limitations, arising from damage to particular areas of the brain, may lead to a specific kind of interaction with the environment. It would be of value to investigate how specific cognitive factors, like executive dysfunction, problem solving difficulties, memory impairments effect behavioural contingencies. The acquired brain injury field may benefit from more extensive research into the neurological underpinnings of challenging behaviours. These contributory factors should set the general context for functional assessments and inform ongoing neurorehabilitation efforts.

A second recommendation arising from the work contained in this thesis relates to the use of functional communication training. Given that the empirical studies have provided strong support that challenging behaviours are operants, it is highly feasible that challenging behaviours have a social communicative function. In this respect, challenging behaviours may serve to provide a way to communicate with the environment. This possibility is likely given that language impairments are a common consequence of traumatic brain injury. The link between communicative behaviours and challenging behaviours has been well established in intellectual disability field. However, considerably less attention has been afforded to functional communication training as a viable intervention approach in the brain injury literature. Functional equivalence training, which is based on behavioural principles, involves learning an adaptive communicative response that is an efficient and functionally equivalent alternative to the challenging behaviour. Strategies to teach alternative communicative behaviours to enhance social communication skills are scarce in neurorehabilitation settings.

The last recommendation concerns the call for a structured assessment protocol to be used in the field of traumatic brain injury. A standard for conducting functional assessment in a systematic and efficient way would be highly advantageous to the neurorehabilitation field. It could offer different functional assessment strategies at different stages. This could be especially pertinent to the assessment of new admissions. Any such information would be transferable across different rehabilitation settings. A standardised assessment protocol may ultimately be linked to different kinds of effective therapeutic interventions.

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Appendix A

Studies excluded from table of evidence

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
McMillan, Papadopoulos, Cornall and Greenwood (1990).	Single subject, baseline-intervention design.	F., 38 yrs old, <1 yr post-injury, severely impaired cognitive abilities, pervasive memory deficits.	(a) Physical aggression, (b) Inappropriate sexual behaviours.	Not reported.	(a) Differential reinforcement of other behaviour, positive punishment (restraint), (b) Differential reinforcement of other behaviour, social disapproval.	(a) 4 weeks, (b) 10 weeks. Residential rehabilitation unit.	Not reported.	<i>Too few datum points</i>	Anecdotal claims, after 3 months, that rates were maintained successfully.
Peters, Gluck and McCormick (1992).	Single subject, baseline-intervention design [P1, P3] / Single subject, alternating treatments design [P2].	[P1] M., 26 yrs old at injury onset, generalised intellectual impairments. [P2] M., 23 yrs old at injury onset, wheelchair used. [P3] M., 21 yrs old at injury onset, extremely poor communication skills. [Other study participant was excluded.]	[P1] (a) Screaming, (b) Absconding behaviours, physical aggression, verbal aggression [combined]; [P2] Screaming, head-banging, verbal aggression [combined]; [P3] Physical aggression.	ABC-type recording chart –[P1] behaviours considered to be negatively reinforced by escaping demands; [P3] behaviours considered to be negatively reinforced by escaping aversive environment.	[P1] Time out; [P2] Differential reinforcement of alternative behaviour with incremental changes in the reinforcement schedule; [P3] Positive punishment (restraint), time out.	[P1] 22 weeks; [P2] 16 weeks; [P3] 13 weeks. Residential rehabilitation unit.	Not reported.	[P1] (a) 0.91 (b) 0.77 [P2] <i>Too few datum points</i> [P3] <i>Too few datum points</i>	Anecdotal claims, after 1 and 2 months [P1] / after 1 year [P2], that rates were maintained successfully.

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Manchester, Hodgkinson, Pfaff and Nguyen (1997).	Single subject, baseline-intervention design.	M., 17 yrs old, <1 yr post-injury, profound impairment of intellectual functioning.	Absconding behaviours.	Unspecified – behaviour considered to be negatively reinforced by escaping aversive environment.	Token economy, with incremental expectations.	13 weeks. Residential rehabilitation unit.	Not reported.	<i>Insufficient datum points</i>	Anecdotal claims, after 3 months, that rates were maintained successfully.
Slifer, Tucker, Gerson, Sevier, Kane, Amar and Clawson (1997)	Single subject, multiple baseline, across-subjects design.	[P1] F., 16 yrs old, 16 days post-injury. [P2] F., 17 yrs old, 13 days post-injury. [P3] F., 16 yrs old, 2 months post-injury.	(a) non-compliance, (b) disruptive behaviours.	Not reported.	Antecedent control (choice, decreasing environmental stimulation, earned escape), differential reinforcement of alternative behaviour, extinction.	– Residential rehabilitation unit.	Not reported.	<i>Unclear data</i>	Not reported.
Alderman, Davies, Jones and McDonnell (1999).	Single subject, baseline-intervention design.	[P1] M., 34 yrs old, <1yr post-injury, pervasive memory deficits. [P2] F., 45 yrs old, 3 yrs post-injury, severely impaired cognitive abilities, hemiparesis. [Other study participant was excluded.]	[P1] Physical aggression, verbal aggression [combined]. [P2] Noncompliance, physical aggression [combined].	Not reported.	[P1 & P2] Contingent positive reinforcement, extinction, positive punishment (restraint), token economy.	[P1] 5 weeks. [P2] 6 weeks. Residential rehabilitation unit.	Not reported.	<i>Insufficient datum points</i>	[P1 & P2] Follow-up conducted but insufficient data provided to measure outcome.

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Fluharty and Glassman (2001).	Single subject, baseline-intervention design.	M., 23 yrs old, impaired cognitive abilities, pervasive memory deficits.	M., 23 yrs old, impaired cognitive abilities, pervasive memory deficits. (a) Physical aggression, (b) Verbal aggression	Not reported.	Antecedent control (feedback), cues.	100 days. Residential rehabilitation unit.	Not reported.	<i>Insufficient datum points</i>	Anecdotal claims, after 4 months, that rates were maintained successfully.
Watson, Rutterford, Shortland, Williamson, and Alderman (2001).	Single subject, baseline-intervention design.	M., mid-30s, 10 yrs post-injury, moderate impairment of intellectual functioning, pervasive memory deficits.	Physical aggression, verbal aggression [combined].	Overt Aggression Scale Modified for Neurorehabilitation – behaviours considered to be positively reinforced by receiving social attention.	Differential reinforcement of low rates of responding (replaced by differential reinforcement of incompatible behaviour), extinction, token economy with incremental expectations.	85 weeks. Residential rehabilitation unit.	Not reported.	<i>Insufficient datum points</i>	Not reported.
Alderman (2003).	Single subject, baseline-intervention design.	M., 5yrs post-injury, severely impaired executive abilities, pervasive memory deficits, hemiparesis. [Other study participant was excluded.]	Verbal aggression.	Unspecified – behaviour considered to be negatively reinforced by escaping (physical) demands.	Differential reinforcement of low rates of responding, with incremental changes in the reinforcement schedule, token economy, informational feedback.	140 days. Residential rehabilitation unit.	Not reported.	<i>Unclear data</i>	Follow-up conducted but insufficient data provided to measure outcome.

Study	Design	Participants	Target Behaviours	Functional Assessment	Intervention Techniques	Duration / Setting	Reliability	Outcome	Maintenance
Pace, Dunn Luiselli, Cochran and Skowron (2005).	Single subject, alternating treatments, across settings design [a] / Single subject, alternating treatments design [b].	M., 10 yrs old, 9yrs post-injury.	(a) Physical aggression, (b) Self-injury.	Unspecified – behaviours considered to be positively reinforced by receiving social attention.	Antecedent control (choice, task sequencing, visual schedules), non-contingent proprioceptive reinforcement, positive punishment (restraint, time-out).	(a)(i) Residential setting, about 6 months, (ii) School setting, about 6 months, (b) 126 sessions. Special education facility.	Not reported.	(a) <i>Unclear data</i> (b) <i>Insufficient datum points</i>	Not reported.

Appendix B

Confirmation of ethical approval

[Page unavailable, in electronic version.]

[Page unavailable, in electronic version.]

Appendix C

Information sheet and consent form for participants with consensual capacity

Watching How People at the Hospital Behave

I shall tell you about a project being done here at <Hospital>. Then you can decide if you want to take part in this project. The project is about people like you who have hurt themselves. The project is about watching how people at our hospital behave. I want to know what people do here and why they do it. The project may help staff get to know you better. The staff may make new treatment plans for you. This may help you get well sooner.

If you want to take part in this project then you'll be watched by me. I shall watch you for a couple of hours each day for about a week. I'll use my little computer to write down the things that I see. I want to see how you get on with the staff. I want to see how you get on with your activities. Your day time routine will be the same though. You will not need to do anything different. Everything will be normal except that I shall watch you sometimes.

If you don't like to be watched then you should not take part in this project. If you don't take part then that's ok. Nothing will happen to you. You will not be made to take part if you do not want to.

If you do take part in this project then I'll need to speak to the staff about you. Also I'll need to read your medical notes. If you don't want me to then you should say so. If you do take part then you'll need to sign a form.

If you say that you want to take part but then change your mind later then that's ok. You can change your mind whenever you like. You don't even have to explain why you've changed your mind.

One day I'll write about the things that I've seen at the hospital. When I do, though, I promise to keep your name a secret. No one will know that I watched you.

We can now talk about the project together. Let me know if you didn't understand anything. Ask me as many questions as you want.

Title of Project:

Watching How People at the Hospital Behave

Researcher:

Mr. Barzan Rahman

Did you understand the sheet you have been read?	Yes / No
Were you allowed to ask questions and talk about the work?	Yes / No
Do you have any other questions that you still want to ask?	Yes / No
Do you understand that you're allowed to change your mind	
- at any time?	Yes / No
- and don't have to say why?	Yes / No
- and nothing will happen to you?	Yes / No

Do you give agree to take part in the project?	Yes / No
--	----------

Signature	Date
Name (Please PRINT) .....	.....
.....	

Researcher's Signature	Date
Researcher's Name .....	.....
.....	

Confidentiality and Data Protection

We will always keep your name a secret.

No one will know that it was you who took part in the project.

Appendix D

Covering letter, information sheet and consent form for participants without consensual capacity

<Advocate Name> <Advocate Family Name>
<Address_1>
<Address_2>
<Address_3>
<Address_4>
<Address_5>

Barzan Rahman
Postgraduate Research Student
Clinical Psychology Department
University of Birmingham
Edgbaston Park Road
Birmingham
B17 0HU

<Date>

Dear <Title> <Advocate Family Name>,

Re: <Name> <Family Name>

I am a postgraduate student currently researching the nature of difficult behaviours, displayed by those with acquired brain injury. With the help of staff and patients at <Hospital>, I will be conducting a study using an observational method of assessment. This will involve observing patients unobtrusively during their normal everyday activities.

It is hoped that the investigation will provide us with some insight into the reasons for difficult behaviours. The information from the observations will be coded to maintain the anonymity of the participant and the data will be stored in accordance with the Data Protection Act.

The team of psychologists have identified <Name> as being suitable for this research. Consequently, the Registered Medical Officer has given me your name as the designated advocate for <Name>. I am writing to inform you of the study and ask that you consider consenting to <Name>'s participation.

I have included an information sheet, which provides more detail about the research, and a consent form. If you would like to discuss any point in more detail then please do not hesitate to contact me, on the number given on the enclosed information sheet.

I look forward to your response.

Yours sincerely,

Barzan Rahman, B.Sc.

Analysis of Behaviour Problems After Acquired Brain Injury

We have designed this information sheet to provide you with some details about a research project being carried out at <Hospital>. We hope to give you all the facts so that you can make an informed decision as to whether you wish <Name> to take part. If we have missed something out or you need a point to be made clearer then please contact Barzan Rahman (<Telephone>).

The investigation, which is concerned with people's behaviour after acquired brain injury, seeks to explain the possible reasons for difficult behaviour. If we can understand what purpose these behaviours serve then we can begin to teach alternative, more acceptable behaviours that that will enable <Name> to engage as fully as possible in the ward programme and ultimately achieve their full rehabilitation potential

<Name> has been selected as being suitable for this research, due to the behaviours that <he/she> exhibits. We hope to recruit a total of ten participants for the study. Participation is a completely voluntary process. If you agree for <Name> to take part, we ask that you sign the attached consent form and keep this information sheet. However, if you do sign the form and then change your mind, you'll be free to withdraw your consent at anytime, without the need to offer a reason. Clearly non-participation in this study will have absolutely no affect on <Name>'s rehabilitation.

The study is observational in nature. It will involve watching <Name> during <his/her> normal everyday activities; <he/she> will not be required to 'do' anything for the study. <Name> may possibly feel some discomfort if <he/she> became aware of being observed. However, before commencing with the study, <Name> will be forewarned that <he/she> will be observed and informed that <he/she> may withdraw at any time.

The study may prove to benefit <Name>'s intervention programme in that the information collected may be reviewed by the clinical team and used to inform the clinical process. It may assist the clinical team in understanding the reasons as to why <Name> behaves as <he/she> does, and it may help them devise appropriate treatment programmes whose aim will be to assist <Name> to achieve <his/her> full rehabilitation potential. The outcome of the study as a whole may also help other clinicians treat their patients at other brain injury rehabilitation centres.

The research would require asking staff some questions about <Name>'s care and reading some of the notes written about <him/her>. However <Name>'s confidentiality will be ensured through out. In addition, <he/she> will remain anonymous in the study and will

not be identifiable. The report will be published in three years and you'll be able to obtain a copy of the results from the Clinical Neuropsychologist at <Hospital>.

The project is funded and organised collaboratively between the University of Birmingham and <Hospital>.

Title of Project:

Analysis of Behaviour Problems After Acquired Brain Injury

Researcher:

Mr. Barzan Rahman

Have you read and understood the information sheet?	Yes / No
Have you had the opportunity to ask questions and discuss this study?	Yes / No
Have you any outstanding questions that you wish to be answered?	Yes / No
Do you understand that you are free to withdraw consent	
- at any time?	Yes / No
- without having to give a reason?	Yes / No
- without medical care or legal rights being affected	Yes / No

Do you give consent for <Name> <Family Name> to take part in the study? Yes / No

Signature	Date
Name (Please PRINT) .....	.....
.....	

Researcher's Signature	Date
Researcher's Name .....	.....
.....	

Confidentiality and Data Protection

Data kept on computer is coded so that it cannot be linked to the participant's name. The project complies with the requirements of the Data Protection Act.

Appendix E

Agreement indices

Data collected using observational methods can be unduly affected by situational influences, coding procedures or the idiosyncrasy of the observer. To determine that findings have not been undermined by such factors it is necessary to demonstrate the data is reliable. The reliability of data is a necessary condition for its validity but it is not sufficient in and of itself. Reliability can be conceived as a broad concept relating to the “dependability, consistency, predictability, and stability” of scores (Suen & Ary, 1989, p. 99). Statistical procedures are employed to establish the replicability of the data by other independent observers. This is done by analysing the extent to which multiple observers agree on measurements of the same behaviours. The terms interobserver agreement and interobserver reliability are used interchangeably sometimes. However it is more favourable to distinguish observer agreement from reliability (Mitchell, 1979; Bakeman & Gottman, 1997). The reason for this distinction relates to the fact that the term reliability can be conceived more specifically as a psychometric concept. In this classic sense, reliability concerns the mathematical relationship between the observed score, the true score and the measurement error or variance (Cordes, 1994).

Psychometric reliability is the outcome of statistical techniques that estimate the consistency of data when a single observer measures the same data set repeatedly. However, such test-retest reliability measures are inappropriate when live observations are conducted without recording devices. Although it would be possible to measure the internal consistency of the data still. This could be done by splitting the data set into half and examining the association between each of the components, using techniques such as Pearson’s product moment correlation. However, since the true variance cannot be known, the theoretical legitimacy of intraobserver reliability would necessitate numerous assumptions to be satisfied. Such statistical limitations mean that if any assumptions were not met then the outcome would not be a true estimate of reliability. Though unusual, it is permissible to apply these techniques to multiple sets of data obtained from multiple observers. However the coefficient would relate the extent of shared variability of the observers’ scores only. It would not explain the degree to which multiple judges agreed on the ratings of a particular item. In this respect such outcomes should not be applied or interpreted in the same way (Burry-Stock, Shaw, Laurie, & Chissom, 1996).

For these reasons, the study used interobserver agreement to consider reliability in the general sense. A coefficient of agreement was needed to gauge the extent to which independent observers agreed on the occurrence of behaviours. Various indices of observer agreement exist that differ in terms of their stringency. A brief scenario is provided to highlight the main differences in approach to interobserver agreement. In the given example a

one-minute observation session is conducted by two observers using partial-interval sampling with 3 second intervals. Each interval is assigned a score. A score of 1 indicates the target behaviour occurred at any time during that interval and a score of 0 indicates its non-occurrence. The hypothetical nominal data set reported by both observers is shown in Figure E.1.

Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Observer 1	1	1	1	0	1	0	1	0	0	0	1	0	0	0	0	1	1	0	1	1
Observer 2	1	0	0	0	1	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1

Figure E.1 Hypothetical data collected by two observers

The results of the data for both observers can be conveniently summarised in a square contingency table, as shown in the left panel of Figure E.2. In this agreement matrix, cells *b* and *c* both represent the instances of agreement on the presence and absence, respectively, of the behaviour. The number of disagreements between the observers are represented in cells *a* and *d*. Cell *a* represents errors of omission, whereby the primary observer records the behaviour as being present but the second observer states it as absent. Cell *d* represents the other type of discrepancy, known as an error of commission. Here the behaviour is recorded as absent by observer 1 but present by observer 2. The scores in interval 2, 5, 8 and 9 would contribute to toward the frequency total of cells *a*, *b*, *c*, and *d*, respectively. The right panel of Figure E.2 presents a 2 x 2 table that is essentially the same as the agreement matrix on the left but with proportions instead of frequencies.

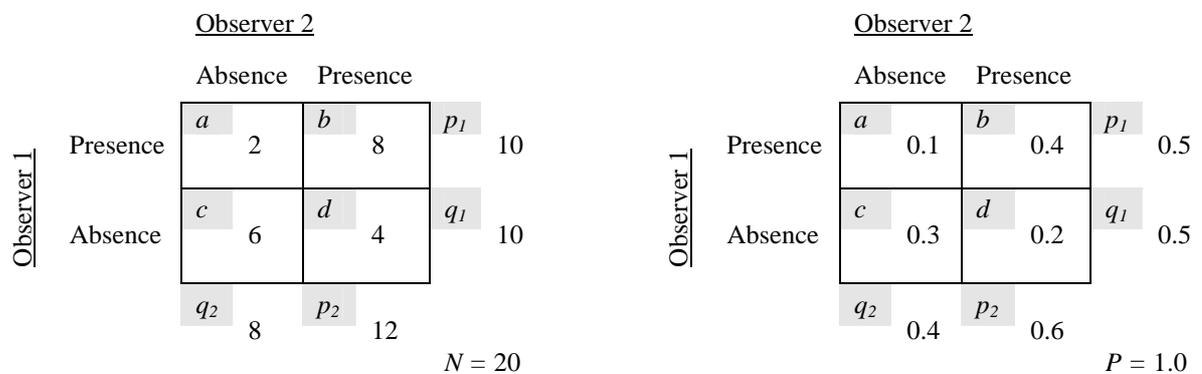


Figure E.2 2 x 2 tables of hypothetical data expressed in both frequencies and proportions

The most basic interobserver agreement measure is the smaller / larger index. This agreement index shows the proportion of agreement by dividing the smaller frequency

occurrence value by the larger value. In the example, observer 1 records 10 occurrences of the behaviour in total (p_1) and observer 2 records 12 occurrences of the behaviour (p_2). The smaller / larger (S/L) index is calculated as follows:

$$\begin{aligned} S/L &= \frac{\text{smaller occurrence}}{\text{larger occurrence}} \\ &= \frac{10}{12} \\ &= 0.8\bar{3} \end{aligned}$$

This measure of agreement is essentially flawed because the index does not take into account actual concurrence. It is unclear whether the occurrences of the behaviour recorded by one observer are the same as those recorded by the other. The index is based on the incorrect assumption the incidences recorded by the observer with the greater total are the same as those identified by the other observer with the lower total. Errors of commission and omission are not enumerated for in the index. As such it is possible for both observers to be in complete disagreement and yet still have identical occurrence totals.

A more popular index that addresses this important deficiency is the percentage agreement index. This agreement index specifically considers actual agreements. It relates to the proportion of agreements as a proportion of the total number of disagreements plus agreements. The percentage agreement index ($p\%$) is calculated as follows:

$$\begin{aligned} p\% &= \frac{\text{no. of agreements}}{\text{no. of agreements} + \text{no. of disagreements}} \times 100 \\ &= \frac{b+c}{b+c+a+d} \times 100 \\ &= \frac{8+6}{8+6+2+4} \times 100 \\ &= \frac{14}{20} \times 100 \\ &= 70\% \end{aligned}$$

Although this measure of agreement is popular, the index is limited by its tendency to over estimate agreements level. The measure makes no account of agreements that would have happened by chance. A certain amount of agreement would be expected by chance alone. For instance, if observer 2 were spuriously to record occurrence or non-occurrence throughout all the intervals then the resultant percentage agreement in both cases would be 50%. Given this element of chance, the percentage agreement coefficient is strongly influenced by the rate of target behaviours and the overall length of the observation time. High percentage agreement values would be expected when the behaviour occurs at a high rate (Hartmann, 1977). This issue can be resolved to some extent by calculating the effective

percentage agreements for occurrence alone or non-occurrences alone. However the effect of chance agreements would still remain. Furthermore percentage agreement indices lack a meaningful lower limit of acceptability and are not amenable to direct comparison since they are not standardised.

The recommended interobserver agreement index, which was used in this study, is the Kappa (κ) coefficient (Cohen, 1960). Cohen's Kappa coefficient is standardised and also deals specifically with the issue of expected agreements. Kappa presents the proportion of 'true' agreement after chance agreement has been discounted. It is the least contentious of the agreement indices. It offers a more stringent and precise measure of agreement. Consequently it has been widely applied to many different kinds of data. Between 1970 and 2006 Cohen's Kappa had been cited in over 6500 publications (Social Sciences Citation Index). Cohen's Kappa (κ) is defined as:

$$\kappa = \frac{p_o - p_c}{1 - p_c}$$

where;

p_o = proportion of agreements observed

p_c = proportion of agreements expected by chance

To summarise the definition in words, Kappa is a ratio of achieved non-chance agreements to the total possible non-chance agreement. The denominator serves to standardise the statistic. The index is calculated below for the hypothetical data set, presented in the 2x2 matrix in Figure E.2.

The p_o is the likelihood that both observers record occurrence or non-occurrence.

Hence,

$$\begin{aligned} p_o &= b + c \\ &= 0.4 + 0.3 \\ &= 0.7 \end{aligned}$$

The p_c is derived by using basic probability theory to calculate the likelihood that both observers record either occurrence or non-occurrence. The probability that both will score an event (occurrence or non-occurrence) is derived by multiplying their simple probabilities of each observer recording that event. Then by summing the chance probability for both categories gives the likelihood of agreement expected by chance. Hence,

$$\begin{aligned} p_c &= (p_1 \times p_2) + (q_1 \times q_2) \\ &= (0.5 \times 0.6) + (0.5 \times 0.4) \\ &= 0.3 + 0.2 \\ &= 0.5 \end{aligned}$$

Then, Cohen's Kappa can be completed as follows:

$$\begin{aligned}\kappa &= \frac{p_o - p_c}{1 - p_c} \\ &= \frac{0.7 - 0.5}{1 - 0.5} \\ &= \frac{0.2}{0.5} \\ &= 0.4\end{aligned}$$

From these demonstrations, using the same worked example, it is clear that each of the three techniques for calculating interobserver agreement produce coefficients of a substantially different magnitude (0.83 / 0.7 / 0.4). Cohen's Kappa consistently produces the lowest index of agreement. Indeed the resultant Kappa coefficient may be underestimated since it is based on the assumption that agreement obtained by chance was in fact actually achieved by chance. The fact that Kappa is so conservative should be reason enough for it to be the measure of choice.

The values of Kappa range from -1.00 to $+1.00$. A positive Kappa index indicates that agreement between observers is more likely than that expected by chance. A value of $+1.00$ represents complete agreement. A negative Kappa index indicates that agreement between observers is less likely than that expected by chance. This means that observers disagree more frequently than would be expected by chance. A zero value indicates that the agreement level is no more or less than that expected by chance.

The magnitude of Kappa can be interpreted using recognised standards. These are essentially arbitrary but they form benchmarks for levels of acceptability. In their influential paper Landis and Koch (1977, p.165) assigned the following labels to ranges of Kappa: $0 \leq$ poor, $0 < \text{slight} \leq 0.2$, $0.2 < \text{fair} \leq 0.4$, $0.4 < \text{moderate} \leq 0.6$, $0.6 < \text{substantial} \leq 0.8$, $0.8 < \text{almost perfect} \leq 1.0$. A revision by Shrout (1998, p.308) shifted the original adjectives to the next interval and provides more delineation at the lower end: $0 < \text{virtually none} \leq 0.1$, $0.1 < \text{slight} \leq 0.4$, $0.4 < \text{fair} \leq 0.6$, $0.6 < \text{moderate} \leq 0.8$, $0.8 < \text{substantial} \leq 1.0$. In this study a value of 0.4 was determined to be a clinically meaningful minimum magnitude (Sim & Wright, 2005).

Appendix F

Operational definitions and kappa values of component behaviours that make up challenging behaviour topographies

Challenging Behaviour	Behaviour Form	Operational Definition		Kappa Values Attained for Participants (Presence and Onset)								
				1	2	3	4	5	6	7	8	9
Verbal aggression	Mild outburst	A directed or non-directed outburst vocalised above a normal conversational volume	Presence	1.0	.80	.92	.50	.82	.67	.50	-	.31 / .68
			Onset	1.0	1.0	.59	.50	.50	.44	.40	-	.36 / .43
Verbal aggression	Moderate verbal aggression	Mild personal insult (not including swearing) directed at another person	Presence	.89	-	.61*	-	-	.40	.33 / .61	-	.61*
			Onset	.89	-	.61*	-	-	.40	.33 / .61	-	.61*
Verbal aggression	Strong verbal aggression	Swearing or moderate threats directed at another person	Presence	.74	-	.89	-	-	.66	.56	-	.66*
			Onset	.74	-	.89	-	-	.66	.56	-	.66*
Verbal aggression	Extreme verbal aggression	Threats of violence directed at another person	Presence	-	-	-	-	-	.87	-	-	-
			Onset	-	-	-	-	-	.87	-	-	-
Self-injury	Head banging	Using the head to make forceful or audible contact with an object	Presence	-	-	.83	.85*	-	-	-	-	-
			Onset	-	-	.83	.85*	-	-	-	-	-
Self-injury	Self-hitting	Using the hand or arm to make forceful or audible contact with any body part of the self	Presence	-	-	.97	-	-	-	-	.91*	-
			Onset	-	-	.97	-	-	-	-	.91*	-
Self-injury	Self-biting	Closing the upper and lower teeth around the flesh of any body part of the self	Presence	-	-	.56*	.56*	-	-	-	.55	-
			Onset	-	-	.53*	.53*	-	-	-	.53	-

Challenging Behaviour	Behaviour Form	Operational Definition		Kappa Values Attained for Participants (Presence and Onset)								
				1	2	3	4	5	6	7	8	9
Physical aggression	Grabbing	Closing the hand around the clothing or any body part of another person	Presence	–	.29 / .68	1.0	.68*	–	.83	.67	.68	.68*
			Onset	–	.50	1.0	.61*	–	.78	1.0	.42	.61*
Physical aggression	Hitting	Using the hand or arm to make forceful or audible contact with any body part of another person	Presence	–	.78	.52*	.52*	–	.55	.30 / .52	.52*	.52*
			Onset	–	.78	.52*	.52*	–	.55	.30 / .52	.52*	.52*
Physical aggression	Kicking	Using the foot or leg to make forceful or audible contact with any body part of another person	Presence	–	.55*	.55	.50	–	1.0	.73	.55*	.55*
			Onset	–	.55*	.55	.50	–	1.0	.73	.55*	.55*
Physical aggression	Pinching	Closing fingers, usually the index finger and thumb, around the clothing or any body part of another person	Presence	–	–	.50	–	–	–	–	–	–
			Onset	–	–	.67	–	–	–	–	–	–
Physical aggression	Punching	Using a closed hand (fist) to make forceful or audible contact with any body part of another person	Presence	–	–	–	–	–	.42*	.43	–	–
			Onset	–	–	–	–	–	.42*	.43	–	–

Appendix G

Summary statistics of challenging behaviours removed from analyses

Participant	Primary and Secondary Challenging Behaviours	Variable Type	Proportion of Total Time (%)	Median Duration (sec)	Frequency	
					Total	Per Hour
1	Grabbing	Duration	0.03	2	4	0
2	Self-biting	Duration	0.00	1	3	0
2	<i>Sexually inappropriate</i>	<i>Duration</i>	<i>0.10</i>	<i>13.20</i>	5	0.3
3	Spitting*	Event	0.01	1	3	0
5	Grabbing	Duration	0.00	2	1	0
5	Self-biting	Duration	0.01	1	6	0
5	<i>Sexually inappropriate</i>	<i>Duration</i>	<i>0.02</i>	3	3	0.2
6	Hair pulling*	Duration	0.00	2	2	0
6	Pushing*	Event	0.00	1	2	0
6	Self-biting	Duration	0.00	1	1	0
6	Spitting*	Event	0.00	1	2	0
7	Self-biting	Duration	0.00	1	1	0
8	Mild outburst	Duration	0.02	1	7	0
8	Property destruction	Event	0.00	1	2	0
9	Property destruction	Event	0.03	1	9	0
9	Pushing*	Event	0.02	1	6	0
9	Self-biting	Duration	0.00	1	1	0

Key:

Primary challenging behaviours (normal font)

Secondary challenging behaviours (italicised)

* excluded due to low occurrence (total frequency was below 10 or proportion of total time was less than 0.1 %). Note, these cases were not included as part of the generic physical aggression topography because there was also an absence of interobserver agreement. The behaviour at no stage, not event across all participants, was seen by the second observer.

Appendix H

Operational definitions and kappa values of secondary challenging behaviours filtered from analyses

Secondary Challenging Behaviour of Participant		Operational Definition	Kappa	
			Onset	Presence
2	Sleeping	A motionless state, of sitting or lying, that occurs when the eyes are closed	.43	1.0
4	Lying	A motionless prostrated state, either on the floor or on a table, that occurs when the eyes are open	.54	.99
4	Sleeping	A motionless state, of sitting or lying, that occurs when the eyes are closed	.70	.99
5	Sleeping	A motionless state, of sitting or lying, that occurs when the eyes are closed	.61	.97
6	Sleeping	A motionless state, of sitting or lying, that occurs when the eyes are closed	.72	.99

Appendix I

Summary statistics of secondary challenging behaviours filtered from analyses

Participant	Secondary Challenging Behaviour	Variable Type	Proportion of Total Time (%)	Median Duration (sec)	Frequency	
					Total	Per Hour
2	Sleeping	Duration	5.63	305	8	0.5
4	Lying	Duration	19.74	154	18	0.7
4	Sleeping	Duration	12.39	156	15	0.6
5	Sleeping	Duration	5.03	203	6	0.3
6	Sleeping	Duration	24.54	54	136	5.6

Appendix J

Conditional probability, odds ratio and Yule's Q

Operant principles of behaviour contend that human or animal behaviour affects and in turn is affected by environmental events. Behaviours are considered to be serially dependent along a time continuum. A particular behavioural event at any moment is related to behaviours that occurred previously. Time series analysis is the application of statistical techniques to untangle serially dependent data. According to Gottman and Roy (1990), the primary goal of sequential analysis is the discovery of stochastic processes and sequences which characterise the data. The other aim is to measure the effect of explanatory variables on the sequential structure.

The discovery of stochastic orders within data requires time series analyses to be expressed in the form of probabilities. A hypothetical example will be used to demonstrate elements of a time-series analysis on a sequence of event data. The example of a chain of mutually exclusive and exhaustive events is presented Figure J.1. Events are recorded once every 3 seconds for a minute. Three behaviours, X, Y or Z, are recorded in each of the twenty intervals.

X | Y | X | Y | Z | Z | X | Z | X | Z | X | Y | Y | Z | Z | Y | Y | Z | X | Y

Figure J.1 Hypothetical example of a chain of mutually exclusive events

The data can be summarised using a simple probability statistics for each behaviour, as follows:

$$\begin{array}{lll}
 p(X) = \frac{n(X)}{n} & p(Y) = \frac{n(Y)}{n} & p(Z) = \frac{n(Z)}{n} \\
 = \frac{6}{20} & = \frac{7}{20} & = \frac{7}{20} \\
 = 0.3 & = 0.35 & = 0.35
 \end{array}$$

Simple probabilities however are not contingent on the expected occurrences of other behaviours. Such simple probabilities offer no basic value in beginning to estimate likely chain of events. From the sequence in the example it can be seen, by simply counting the frequency of incidences, that event X occurred six times. Of these six times, X was directly followed by Y on four occasions. The conditional probability that Y will occur given the occurrence of X previously is written and calculated as follows:

$$p(Y_{+1}|X) = \frac{4}{6} = 0.667$$

This conditional probability is referred to also as a transitional probability. Transitional probabilities convey information regarding the likelihood of one event passing

from a previous event. Counting the frequency of pairs of data can be done in a more systematic manner using the moving time window technique, as shown in Figure J.2.

Hypothetical data	X	Y	X	Y	Z	Z	X	...	
Step 1	(X	Y)	X	Z	Z	Z	X	...	Incident of Y occurring directly after X
Step 2	X	(Y	X)	Z	Z	Z	X	...	Incident of X occurring directly after Y
Step 3	X	Y	(X	Z)	Z	Z	X	...	Incident of Z occurring directly after X
Step 4	X	Y	X	(Z	Z)	Z	X	...	Incident of Z occurring directly after Z
...etc...	...	...	...	...	...	...	...	...	...etc...

Figure J.2 Hypothetical example of counting frequencies of incidences using the time window technique

The time window in this example is two time units wide (i.e. six seconds). However the window could be as large as desired. Also the transitional probabilities can also describe associations between non-adjacent events too. For instance the term $p(Y_{+3}|X)$ refers to the likelihood of Y occurring given that X had occurred three time units previously. Indeed, as mentioned later, an analysis of co-occurrence is also possible. This considers the likelihood of both events occurring concurrently in the same time window.

The frequency data can be presented in a matrix, as shown in Figure J.3. The rows of the matrix represent the distinct events at time t. The columns represent the target events at time t+1, given that the corresponding event occurred at time t. The corresponding probabilities for the cells can then be calculated, as shown in the transition matrix in Figure J.4.

		<u>Time t+1</u>				
		<u>(Target code)</u>				
		X	Y	Z		
<u>Time t</u>	<u>(Given code)</u>	X	0	4	2	6
		Y	1	2	3	6
		Z	4	1	2	7
			5	7	7	19

Figure J.3 Frequency state transition matrix of the hypothetical data

		<u>Time t+1</u>				
		<u>(Target code)</u>				
		X	Y	Z		
<u>Time t</u>	<u>(Given code)</u>	X	0.0	0.67	0.33	1.0
		Y	0.17	0.33	0.5	1.0
		Z	0.57	0.14	0.29	1.0

Figure J.4 Probability state transition matrix of the hypothetical data

The use of conditional probability alone is limited in providing meaningful information. A conditional probability has no real interpretative function. It does not control for the base rate of behaviours. It is recommended that conditional and simple (unconditional) probabilities be compared (Vollmer *et al.*, 2001). This comparative exercise is the basis of sequential analysis.

The state transition matrix can be collapsed into a 2x2 matrix to focus on specific event sequences. For instance, the 2x2 contingency matrix shown in Figure J.5 relates to the likelihood that Y occurs directly following X. The rows represent time t (i.e. lag 0) and the columns represent time t+1 (i.e. lag +1). The symbol ~ signifies 'not' and each individual cell represents the corresponding frequency. To consider the likelihood of Y occurring immediately after X by conditional probability alone is inferior to comparing it with its unconditional reliability. However, there are limitations associated with the comparative analyses. Consideration of the odds ratio gets around the effects of base rates.

		Time t+1		
		Y	~Y	
Time t	X	4	2	6
	~X	3	10	13
		7	12	19

Figure J.5 Contingency table of probable sequences of example data

The odds for Y following X are 4:2 or 2:1. It can be seen that X occurs six times, of which four times it was followed by Y and two times it was followed by an event other than Y. Furthermore, the odds for Y following an event other than X are 3:10. All events other than X occur thirteen times, of which three times they were followed by Y and ten times they were followed by an event other than Y. By comparing the odds, and calculating a ratio of the ratios, it is clear that the odds of Y occurring after X is 6 times greater than the odds of Y occurring after anything else. Thus the magnitude of the odds ratio is 6. The formal presentation of the odds ratio is:

$$\text{estimated odds ratio} = \frac{a/b}{c/d}$$

The odds ratio varies from 0 to infinity and equals 1 when the odds are the same for both rows. The usefulness of the odds ration is limited without a standardised descriptor. Two

mathematic transformations are applied to the odds ratio to form the Yule's Q index. As described in Bakeman, McArthur, & Quera (1996, p.449): firstly, c/d is subtracted from the numerator (so that Yule's Q is zero when a/b equals c/d), then a/b is added to the denominator (so that Yule's Q is +1 when b and/or c is zero and -1 when a and/or d is zero). As such the Yule's Q index varies from -1 to +1 and a value of 0 represents no effect. The formal presentation of Yule's Q is:

$$\begin{aligned} \text{Yule's Q} &= \frac{\frac{a}{b} - \frac{c}{d}}{\frac{c}{d} + \frac{a}{b}} \\ &= \frac{\frac{ad - bc}{bd}}{\frac{bc + ad}{bd}} \\ &= \frac{ad - bc}{bc + ad} \end{aligned}$$

So, for the hypothetical data:

$$\begin{aligned} \text{Yule's Q} &= \frac{ad - bc}{bc + ad} \\ &= \frac{(4 \times 10) - (2 \times 3)}{(2 \times 3) + (4 \times 10)} \\ &= 0.739 \end{aligned}$$

A Yule's Q integer above or equal to 0.5 relates to an odds ratio of 3, indicating that the association was three times more likely than chance to have occurred. A Yule's Q integer above or equal to 0.8 relates to an odds ratio of 5, indicating that the association was five times more likely than chance to have occurred. In this study, a Yule's Q value of 0.5 or above was taken to indicate a significant association.