ATTENTIONAL REORIENTING IN RESPONSE TO SOCIALLY RELEVANT GESTURES:

A NEUROPSYCHOLOGICAL INVESTIGATION

by

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ABSTRACT

The work presented in this thesis explored the effectiveness and reflexiveness of attentional reorienting in response to different types of socially salient gestures. A traditional target detection paradigm was employed across experiments, allowing for the direct comparison of validity effects in response to eye gaze shifts, human pointing gestures, and symbolic arrows. Previous research has tended to compare the effects of eye gaze shifts and symbolic arrows, so this thesis attempted to 'bridge the gap' in the social orienting literature. The effects of these different types of socially relevant stimuli were investigated in three distinct populations. Firstly, we examined whether pointing gestures were as effective as eye gaze shifts in reorienting attention to the impaired hemifield of patients with parietal lobe damage. We then carried out the same set of experiments with a patient displaying an acquired 'theory of mind' deficit, to establish the relative social nature of pointing gestures in comparison to gaze. Finally, we assessed the effects in typically developing adults who display a high proportion of autistic traits, to draw inferences about how these cues are attended to in autistic spectrum disorders. We found that pointing gestures hold a similar social relevance as gaze shifts, and produce largely the same attentional reorienting effects in normal observers. Effects are discussed in terms of reflexive visual attention, neuropsychological disorders, and social cognition, with inferences regarding social networks in the brain.

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CHAPTER 1:

LITERATURE REVIEW

Normal and abnormal human visual attention has long been a topic of interest in psychology, neuropsychology and more recently in cognitive neuroscience. Klein (2000) explains how orienting to salient events is central not only in human attention, but that it is one of the most primitive behaviours of all living things. Attentional orienting in response to biologically relevant stimuli is beneficial to the survival and evolution of non-human organisms, whereas orienting in response to social stimuli lays the foundations for appropriate social communication in humans. The vast majority of research in this area has tended to use central eye gaze and arrow cues to compare the effectiveness and reflexiveness of attentional reorienting in response to these different types of cue. The following literature review will cover topics relating to the orienting of human visual attention to socially salient stimuli. Topics of most relevance for this thesis are the issues surrounding the automaticity of eye gaze processing, how human directional pointing cues are processed and their influence on attention, and the relative cueing effects of symbolic arrows. This review will delve into existing literature surrounding these issues, and explore the findings in normal observers relative to different populations including patients with acquired brain damage, and neurodevelopmental disorders such as autism. In my research, similar experiments will be carried out in order to address research questions which have not yet been explored in these different populations. A traditional target detection paradigm will be used to investigate inversion effects of gaze and pointing cues, and to evaluate the relative validity effects of these different types of cues in relation to symbolic arrows. This literature review will begin with an overview of Posner's classic target detection experiment (Posner, 1980) which forms the basis for all experiments presented within this thesis.

1.1 The Posner Cueing Paradigm

One of the most popular paradigms for investigating automatic (exogenous) and voluntary (endogenous) orienting mechanisms in visual attention was put forward by Michael Posner and colleagues in the 1980s (Posner, 1980; Posner, Walker, Friedrich & Rafal, 1984, 1987; see also Egeth & Yantis, 1997). Exogenous mechanisms operate reflexively to shift attention to elementary properties of stimuli independently of voluntary control, whereas endogenous mechanisms orient attention to stimuli deliberately and according to the viewers' expectations, goals, or understanding of the meaning of the stimuli (Vuilleumier, 2002). Since Posner's cueing paradigm forms the basis for the experiments within this thesis, this section is dedicated to describing the paradigm and Posner's findings in detail.

In Posner's classic paradigm (see Posner, 1980), participants were presented with three horizontal boxes and instructed to fixate the central box. They responded with a key press to a target appearing in either of the two peripheral boxes. A cue preceded the target, and this was either central (an arrow pointing towards one of the peripheral boxes) or peripheral (a brief brightening of one of the peripheral target boxes). There was a high probability that the central cue would point towards the correct target location, and responses were faster for the cued than the uncued target locations (this is known as the cue-validity effect and is generally used to assess the extent of automaticity in attentional reorienting experiments; see Bartolomeo & Chokron, 2002). Under these conditions, it is understood that attention is endogenously cued to the target, since participants are able to predict the target location and so guide their response accordingly.

That is, endogenous orienting reflects a more deliberate, strategic process where attention is directed according to the viewers' goals or prior expectations, and as such is usually seen after longer time intervals between cue and target (around 250-300ms; Peelen, Heslenfeld & Theeuwes, 2004). However, when non-informative peripheral cues are presented (i.e. there is an equal probability of targets appearing at the cued and uncued locations), attention is said to be reoriented exogenously. That is, despite participants knowing that orienting attention in the direction of the cues would not be beneficial in terms of efficient target detection, attention was reoriented rapidly (around 100ms between cue and target onset) and automatically regardless of prior knowledge of cue validity.

'Exogenous' cue conditions (i.e. a brief brightening of a peripheral target box) produce the same facilitatory effect as 'endogenous' cues (i.e. a symbolic arrow), but only when the stimulus onset asynchrony (SOA) between cue and target is less than approximately 250ms (Peelen et al, 2004). At SOAs beyond ~250ms, participants paradoxically respond more slowly to targets at the cued location than those at the uncued location. This phenomenon has been called 'Inhibition of Return' (IOR) and has been explained in terms of maximising efficient exploration of a visual scene by inhibiting the reorienting of attention to previously explored areas (Posner, Rafal, Choate & Vaughan, 1985). It is important to note that IOR only occurs in exogenous orienting conditions (Klein, 2000) and so for example, when participants can accurately predict that a target is likely to appear at the cued peripheral location (i.e. when the peripheral cue is informative), orienting towards the cue location is not inhibited as time between cue and target onset increases. Muller and Findlay (1988) suggest that this effect shows evidence of initial exogenous orienting being overruled by a more strategy-driven, endogenous orienting of attention to the same cued location. To recap, the standard cue-validity effect (i.e. faster RTs in response to cued than uncued targets) is found with exogenous (automatic) and endogenous (strategy-driven) orienting, although this effect occurs more rapidly for exogenous (100ms) than endogenous (300ms) orienting. Furthermore, exogenous orienting is not susceptible to top-down control (i.e. although we know that the target is unlikely to appear at the cued location, we cannot help but automatically orient to that location), and benefits from IOR (so that previously attended areas are not returned to) and hence attention is reoriented more efficiently and rapidly under exogenous than endogenous orienting.

Posner et al. (1984) argued that there are three distinct hypothetical stages of covert orienting of visual attention; i) disengaging from the current focus of attention, ii) reorienting attention towards the new target, and iii) engagement of attention upon the new target. Posner et al. (1984) ran his classic cueing experiment with a group of patients selected on the basis of having parietal damage (six patients with left hemisphere lesions, and seven with lesions to the right hemisphere). The parietal lobes are implicated in visuo-spatial attention, where damage to one or both lobes typically results in visual neglect and/or extinction. Neglect is presented behaviourally as a deficit in spontaneously exploring and attending to the side or space which is contralateral (i.e. on the opposite side) to the lesion. Clinically, neglect usually is diagnosed by a line bisection task, where the patient is asked to indicate the centre of a line. If a patient has right parietal lobe damage and hence tends to neglect the left side of space, the line bisection task will be heavily biased towards the right side for this patient. Extinction reflects a similar visuo-spatial deficit to neglect, except that for extinction the impairment is only seen in situations where two stimuli are presented bilaterally (i.e. one stimulus in each visual field) to the patient. That is, when a patient with visual extinction is presented with two stimuli simultaneously they will fail to report (i.e. they will ‘extinguish’) the stimulus which is presented on the contralesional side.

Extinction is diagnosed clinically by a bilateral stimulation task, whereby the examiner sits in front of the patient and raises both hands so that they appear in the patients' eye-line, to the outer edges of the visual field. The patient is instructed to look straight at the examiner, whilst the examiner moves their fingers on either the left side only, the right side only, or both sides simultaneously. Although the patient can detect unilaterally presented left and right stimulation (i.e. the examiners' finger movements), they are diagnosed with visual extinction if they fail to detect one of the stimuli on bilateral trials (i.e. they report the ipsilesional stimulus, but fail to report - or extinguish - the contralesional stimulus). Posner et al. (1984) wanted to investigate which of the three stages of covert orienting were impaired by parietal lobe damage in patients showing neglect and extinction. Eight of the total thirteen parietal patients were reported as showing evidence of hemispatial neglect, with seven of these same eight patients also showing visual extinction. It is noteworthy that Posner et al. (1984) assumed that "neglect…includes extinction" (Posner et al., 1984, p. 1863) which explains why the patients were not separated in the analysis on the basis of their neurological impairments, but on the side of their lesion[1]. Posner et al. (1984) found that with peripheral cueing, the group of patients presenting with left side parietal lobe damage displayed faster reaction times overall than the patients with damage to the right parietal lobe. However, this effect was largely due to the very long reaction times of the right parietal group on trials where an ipsilesional cue was followed by a contralesional target, particularly following short SOAs. Posner et al. (1984) argued that this pattern of reaction times is akin to visual extinction, and that the effect can be attributed to a deficit in the 'disengaging' stage of orienting attention. Right parietal patients had no problems in orienting attention to a

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[1] See section on *'Neuro-Anatomy of Neglect and Extinction'* in Appendix I for a discussion of the differences between the neural substrates of neglect and extinction.

contralesional cue (shown by no significant difference in detection of cued contralesional and ipsilesional targets at short SOAs), implying that exogenous orienting in both directions is intact. However, it seems that the right parietal-damaged patients display difficulties in disengaging attention from the invalidly cued ipsilesional side when followed by a contralesional target. This effect also occurred when central arrow cues replaced the peripheral cues, although performance was nearly as impoverished when the central contralesional cues were valid as when they were invalid. Furthermore, a neutral cue (a brief brightening of the central fixation box) followed by a contralesional target produced largely the same extinction-like reaction time pattern as peripheral, invalidly-cued contralesional targets. Thus it would seem from Posner et al.'s (1984) research that extinction-like behaviour reflects a deficit in endogenous, strategy-driven orienting of attention to contralesional space, once it has been exogenously oriented and engaged elsewhere (i.e. to central or ipsilesional locations). The effects of social stimuli on attention in parietal-damaged patients will be discussed in the section *1.3 Social Cues and Brain-Damaged Patients*.

1.2 Social Cues and Normal Attention

Research with normal participants has suggested that orienting of attention following another's gaze is indicative of exogenous mechanisms, since this shift of attention seems to occur rapidly and automatically, and regardless of the predictive nature of gaze (Friesen & Kingstone, 1998; Langton & Bruce, 1999; Driver, Davis, Ricciardelli, Kidd, Maxwell & Baron-Cohen, 1999). That is, even when gaze cues are non-predictive or even counter-predictive, participants are unable to suppress their automatic orienting response in the direction of the gaze shift. Therefore, automatic orienting in response to eye gaze cues is extremely resistant to top-down control. However, the very notion of reflexive orienting in response to eye gaze cues has been contested by many researchers. For example, Vecera and Rizzo (2004) argue that the ‘reflexive’ cueing effects for gaze and arrow cues (as reported by Ristic, Friesen & Kingstone 2002; and Tipples, 2002), can be explained by rapid deployment of attention via over-learned associations. That is, associations between the direction of the gaze and arrow cues, and the location to which they refer. Vecera and Rizzo’s (2004) work will be described in more detail in section *1.3. Social Cues and Brain-Damaged Patients*. Researchers from Kingstone’s laboratory (Ristic, et al., 2002) have argued that both gaze and arrow cues can induce exogenous attentional orienting mechanisms. Across a series of three experiments, Ristic et al. (2002) directly compared the relative cueing effects following non-predictive gaze cues and non-predictive arrow cues, in adults, younger children, and a split-brain patient. Since infants orient to faces (Scaife & Bruner, 1975) and follow others’ eye gaze (D’Entremont, Hains & Muir, 1997) from a very early stage of development, Ristic et al. (2002) expected that children may respond reflexively (and hence similarly to adults) to gaze cues in the experiment. However, since children have relatively less experience with symbolic arrows, reflexive orienting to these cues at such a young age was questioned. Nonetheless, they found the same effects of cue-validity in the gaze and arrow conditions across both adults and children, strengthening their claim that reflexive orienting is not restricted to biologically relevant stimuli. (Please refer to the following section *1.3 Social Cues and Brain-Damaged Patients* for a review of Ristic et al.’s findings with split-brain patients).

The exact nature of the processing of symbolic arrow cues has been the centre of much debate over the past two decades. Posner’s original research suggested that central arrow cues induce endogenous cueing effects, which gained support from early experiments (e.g. Jonides, 1981). However, more recently Tipples (2002) has shown that arrows can induce exogenous shifts in normal attention, if the stimulus display is altered to match the configuration of face and eye gaze cues. Tipples (2002) argued that in most research paradigms (e.g. Friesen & Kingstone, 1998) eye gaze cues are actually comprised of *two* cues (the eyes) and a central fixation (the nose). In a cued-detection paradigm, Tipples (2002) presented participants with two arrows either side of a fixation point, which could both point either towards or away from the following cue location. It was found that participants made faster responses to cued than to uncued locations, even after only a 100ms delay between stimulus and target onset. These results occurred despite participants being informed that the arrows would not be reliably indicative of the target location, which suggests that the arrows triggered reflexive, exogenous orienting mechanisms. Tipples (2002) proposed that eye gaze may not be unique in its ability to shift attention automatically, as such reorienting can occur in response to peripherally presented symbolic arrows, which supports the findings of Ristic et al. (2002). However, Ristic et al. (2002) speculate that equivalence in behavioural responses to two different types of stimuli (e.g. eyes and arrows), does not necessarily suggest that the underlying neural substrates involved in the processing are the same. Indeed in a cued-detection fMRI experiment, Kingstone, Tipper, Ristic and Ngan (2004) presented participants with a stimulus which could be perceived as eyes or a car, with the critical manipulation being whether the participants were told that the stimulus was a face or a vehicle. Behavioural results from inside the scanner revealed a significant reflexive cueing effect in response to both car and gaze stimuli, supporting the behavioural findings of Ristic et al. (2002), but most importantly the superior temporal sulcus (STS) was exclusively involved in processing the 'eye' stimulus, but not the car stimulus. These findings support Haxby, Hoffman and Gobbini's (2000) distributed model of social communication, which suggests that face perception is mediated by a *distributed* network and not localised to the fusiform face area (FFA) in the temporal lobe as previously postulated by Kanwisher, McDermott and Chun (1997). Haxby et al. (2000) propose a hierarchical system underlying face recognition and social communication, starting with extrastriate occipitotemporal regions which subserve visual analysis of faces. Further up the hierarchy, in the lateral fusiform gyrus, information is extracted about invariant aspects of the face, i.e. identity, whereas changeable aspects of the face, i.e. eye gaze and expression, are supported by the STS. According to Haxby et al. (2000) the extended system includes the anterior temporal lobe which supports the retrieval of personal information such as a person's name; the amygdala, insula and limbic system which support emotion processing; and the intraparietal sulcus which supports spatially directed attention in response to information from the STS about gaze direction and head orientation (Harries & Perrett, 1991).

Further research has speculated whether there are other areas of the human brain that are specialised for the processing of other biologically and socially relevant information. Neuropsychological research has suggested that semantic knowledge about human body parts may be dissociable from knowledge about other objects (Shelton, Fouch & Carramazza, 1998). Neuroscientific evidence in support of this notion was presented by Downing, Jiang, Shuman and Kanwisher (2001) in a seminal paper reporting the existence of an area in human extrastriate cortex which responds selectively to human bodies. The response was found in an area of the lateral occipital cortex (LOC) and was termed the extrastriate body area (EBA) by Downing and colleagues (2001). The blood oxygen level dependant (BOLD) response in this area was significantly larger when participants were shown images of human bodies than when they viewed a range of other objects and body parts, including faces. This response was not reliant upon image properties, since it was present across a range of different images including photographs, line drawings, stick figures and silhouettes of human bodies (Downing et al., 2001).

Further research by Peelen and Downing (2005) has shown that processing of bodies also occurs in a fusiform region (termed the fusiform body area, or FBA; Schwarzlose, Baker & Kanwisher, 2005) that is located both adjacent to and overlapping the FFA. This area has been found to respond more strongly to headless bodies than to objects, but equally to headless bodies and faces. This finding supports the work of Haxby and colleagues (Haxby, Gobbini, Furey, Ishai, Shouten & Pietrini; 2001) who found overlapping representations of faces and objects in ventral temporal cortex, and also supports Haxby's (2000) distributed model of social attention which argues against the existence of specialised modules for stimulus categories.

Do other socially relevant gestures (besides eye gaze) have a significant effect upon where we orient our attention within our environment? Langton and Bruce (2000) explored the relative interference effect of pointing gestures upon head and eye gaze cues. They found that head direction and pointing gestures exerted significant but independent influences upon the responses to the spoken words, which were 'up' and 'down'. That is, there were separate interference effects of point gesture incongruity and head direction incongruity upon responses to spoken words, but there was no interaction between these two effects. Langton and Bruce (2000) argue that the two cues are processed in parallel, since there was no interaction between head congruency (in terms of the congruency between head direction and the spoken target word) and point congruency (i.e. congruency between point direction and the spoken target word), indicating that both cues exerted an independent influence upon the responses to the spoken words. In a second experiment where head and gesture cues were placed in direct conflict with one another, participants were required to respond to the direction of one cue (e.g. head direction) whilst ignoring the other cue (e.g. point direction). Langton and Bruce (2000) found that the to-be-ignored stimulus exerted a significant interference effect upon the stimulus that was to be responded to. Thus both head and gesture cues appear to be processed automatically (and hence recruit exogenous orienting mechanisms); however, the effects were asymmetrical, such that pointing gestures created greater interference upon responses to head-direction than vice versa. Langton and Bruce (2000) questioned whether this was due to the pointing gestures being more discriminable than the head direction cues, but the fact that to-be-ignored head direction still had a significant interference effect upon responses to pointing gestures precludes this possibility.

Langton and Bruce (2000) proposed a model whereby attentional signals such as eye gaze, head orientation, spoken words and pointing gestures are all processed automatically and in parallel by separate systems. The directional information from each of these systems is then pooled before a response is selected. On this premise, Langton and Bruce (2000) suggested that a target which does not require a directional response will not be influenced by a to-be-ignored directional cue. A third experiment confirmed this hypothesis by showing that irrelevant head direction cues had no influence on non-directional responses (‘*good’* or ‘*bad’*) to non-directional gestures (‘thumb up’ or ‘thumb down’). However, there was an influence of thumb gesture upon responses to head-gaze direction, for which Langton and Bruce (2000) offered two alternative explanations. One possibility is that whilst attending to the head region, low-level cues from the hand area may have allowed for confusion of the thumb for a forefinger, and thus a pointing gesture (Langton & Bruce, 2000). Another possibility is that such hand gestures are processed automatically and directionally when they are not explicitly attended to, but when they constitute the target the task demands override the directional processing and thus there is no interference of the head-gaze cues on non-directional hand gestures (Langton & Bruce, 2000). This latter explanation suggests that when hand gestures appear in the periphery, the directional nature of the stimuli exogenously attract attention, but when the gesture is central to the task, endogenous processes can take over and thus ignore directional influences in accordance with the task demands.

A fourth experiment examined the interference effects of head-gaze cues upon non-social directional stimuli (i.e. arrows). For this purpose, the first experiment was replicated with the use of upwards or downward pointing arrows printed on the chest of the model, rather than pointing gestures. Head-gaze cues had significant interference effects upon directional responses to the arrow. In addition, incongruent arrows seemed to have an interference effect upon downward pointing head-gaze cue (that is, there was a larger effect on downward head direction responses when the arrow pointed upwards, than when the arrow also pointed downwards). Langton and Bruce (2000) suggested that this effect may have arisen owing to the proximity between the face of the model and the arrow head in this condition, which may have forced the to-be-ignored arrow into focal attention and hence increased interference. Overall, Langton and Bruce (2000) confirmed that that eye gaze/head orientation and pointing gestures are attended to automatically in normal observers, thus supporting the findings of Driver et al. (1999; for gaze cues) and Ristic and Kingstone (2006; for pointing cues).

There has been a more recent development in the literature, where fMRI has been used to show that the posterior STS is not only involved in processing directional information from gaze shifts (Perrett, Smith, Potter, Mistlin, Head, et al., 1985) but also from human pointing gestures (Materna, Dicke & Thier, 2008). Materna et al. (2008) also reported a significant difference in participants' behavioural reaction times during the fMRI experiment, where responses were faster following the pointing cues than following gaze cues. These data support the findings of Langton and Bruce (2000) to some extent, since responses to gaze cues may be slower due to the relatively larger amount of interference from the pointing cues. However, Materna et al. (2008) do not offer an account for their behavioural finding, as they claim that the actual difference in reaction times to gaze and pointing cues is very small in comparison to the typical BOLD response (~12s). Although this research informs us of a common brain area (STS) that is associated with the processing of both gaze and pointing cues, it tells us relatively little about the time-course of cognitive responses to each cue. That is, we do not know which cue would attract our attention first in an everyday situation, or how able we are to adapt to ambiguous or invalid cues, and to reorient our attention accordingly. Researchers have begun to compare electrophysiological correlates of attention reorienting in response to gaze shifts with those induced by arrow cues (Brignani, Guzzon, Marzi & Miniussi, 2009). In exploring the differences in cue validity effects between gaze, arrows and a purely endogenous cue (textures with learned directionality), Brignani et al. (2009) discovered not only that gaze and arrows induce very early attentional shifts via an over-learned endogenous mechanism, but that these attentional shifts are mediated by the same neural network. They found cue-validity effects for all types of cues (gaze, arrows and textures) after an SOA of 200ms, but only the gaze and arrow cues produced these standard cue-validity effects at the shortest SOA of 100ms. Analysis of the ERP data showed differences in the amplitude of waveforms but not in the topography, which is suggestive of a different activation of the same neural network across the three types of cue. Given the findings of Materna et al. (2008), we may expect to find similar neural networks and time-courses involved in the processing of gaze and pointing cues using a method with suitable temporal resolution such as EEG (such a study has not yet been reported and is beyond the scope of this thesis).

With the exception of a few papers presented here (Langton & Bruce, 2000; Doherty & Anderson, 1999; Materna et al., 2008) there has been very little research into the cueing effects of human pointing gestures relative to those of eye gaze shifts and arrow cues, and the neural substrates which underpin orienting in response to these different types of visual cue. This niche in the literature forms the basis of the fundamental research question addressed by this thesis. Furthermore, Smilek, Birmingham, Cameron, Bischof and Kingstone (2006) have proposed an alternative approach to studying attention which they refer to as *cognitive ethology*, which attempts to further our understanding of attention to real-world scenes, rather than to relatively artificial stimuli in laboratory conditions. Therefore the final three empirical chapters of this thesis will incorporate more realistic gaze and pointing cues into target detection experiments, as an extension to simple schematic cues (Chapters 3, 4 and 5).

1.3 Social Cues and Brain-Damaged Patients

Previous research with two split-brain patients (Kingstone, Friesen & Gazzaniga, 2000) showed that eye gaze produced reflexive orienting effects, but only when the gaze cue projected to the hemisphere specialised for face processing (left hemisphere for one patient, VJ, and the right hemisphere for the other patient, JW). The effect remained even when the eyes were presented alone, but was absent when the faces were inverted. From these findings, Kingstone, et al. (2000) reasoned that within the temporal lobe, gaze processing can be affected by face processing (since validity effects are eliminated by inversion of the face), but it is not entirely dependent on face processing (since validity effects are found with the eyes alone). However, in a similar study Ristic et al. (2002) tested split-brain patient JW in a cueing task with non-predictive arrows and found significant validity effects in *both hemispheres*. This finding suggests that the neural mechanisms which mediate gaze cueing and arrow cueing are different, and supports the existence of a distinct brain region responsible for processing biologically relevant face and gaze information (Haxby et al., 2000).

Vecera and Rizzo (2004) showed that a patient (EVR) with orbitoparietal damage could reflexively orient his attention in response to exogenous peripheral cues (that is, the brightening of possible target locations, as described in Posner's original experiment). However, the patient showed no such validity effects in response to central gaze cues or central directional word cues (i.e. 'left', 'right'). Vecera and Rizzo (2004) claim that orienting in response to directional gaze and arrow cues is an over-learned behaviour that affords very rapid attentional responses, but does not necessarily imply reflexive orienting. They explain the dissociation seen in patient EVR in terms of damage to the orbitofrontal cortex, which is responsible for learning associations, such as the association between eye gaze direction and the location to which it refers. This then impairs attentional orienting due to these associations either not being acquired during the course of the experiment, or because the previously learned associations are no longer accessible due to brain injury (Vecera & Rizzo, 2004). Since patient EVR could orient in a 'normal' fashion to purely exogenous cues, but not to eye gaze or word cues, Vecera and Rizzo (2004) conclude that attention is oriented via eye gaze voluntarily, not reflexively.

In a separate area of the neuropsychological literature, research has demonstrated that visual extinction can be modulated by the potential social relevance of stimuli. Vuilleumier has presented a wealth of research (Vuilleumier, 2000; Vuilleumier & Schwartz, 2001; Vuilleumier 2002) which exploits the social and biological significance of human faces in experiments designed to investigate the potential effect of such salient stimuli on recovery from extinction. Vuilleumier (2002) investigated the effect of perceived eye gaze direction on the orienting of attention in parietal damaged patients who showed clinical signs of hemispatial neglect and visual extinction. Vuilleumier (2002) began by questioning whether perceived eye gaze was an exogenous or endogenous cue for attention, and designed the experiments accordingly, by manipulating validity conditions and stimulus-onset asynchronies (as described below). Driver el al. (1999) reported that eye gaze cues are processed automatically, and as such rely on exogenous mechanisms. However, Vuilleumier (2002) stated that the perception of faces and eye gaze direction relies on specialised processes and the automatic attentional cueing value of gaze depends on its special social meaning, which is in line with Vecera & Rizzo's (2004) conclusions.

In Vuilleumier's (2002) first experiment, patients were presented with faces and meaningless oval shapes, but this time the faces could have their eyes averted towards the opposite field (e.g. a left sided face gazing towards the right) or straight ahead (see Figure 1).

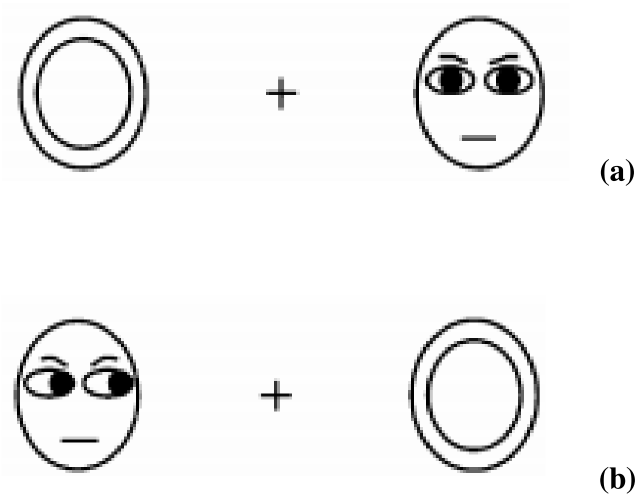

Figure 1. Examples of stimuli presented in bilateral trials in Vuilleumier (2002). (a) Example of a left side shape with a right side face with a straight ahead 'neutral' gaze. (b) Example of a left side face with gaze averted towards the right side shape.

In accordance with previous findings (Vuilleumier, 2000; Vuilleumier & Schwartz, 2001), left sided faces were extinguished significantly less often than left sided shapes on bilateral trials. That is, despite these patients' attentional deficit to the contralesional side, faces appearing on this side were reported more often (i.e. with greater accuracy) than shapes appearing on the neglected contralesional side. Critically, a contralesional shape was extinguished less often when a concurrent ipsilesional face was looking towards the left (i.e. towards the contralesional item), than when it was looking straight ahead. That is, patients were more accurate at reporting the contralesional shape when it was 'looked at' by the ipsilesional face, than when the ipsilesional face looked straight ahead. This effect occurred despite a substantial amount of processing of ipsilesional face cues as determined by their influence on shifting attention to the contralesional side, and thus competed with patients' problems in disengaging attention contralesionally. As such, Vuilleumier (2002) asserted that eye gaze activates strong, reflexive, exogenous orienting mechanisms, in spite of this feature being irrelevant to the task. Furthermore, the effect of eye gaze upon extinction was not replicated by replacing faces with symbolic directional arrows; hence supporting the claim that eye-gaze constitutes an exogenous attentional cue. However, the gaze direction displayed by the contralesional face had no effect on detection accuracy, even in the presence of a simple ipsilesional shape where attention could be arguably biased towards the more visually complex and socially meaningful face. This contradicts Vuilleumier's previous findings (Vuilleumier, 2000; Vuilleumier & Schwartz, 2001), where a left-side face was able to capture attention in the presence of a right-side shape and hence allowed detection of both stimuli. Vuilleumier (2002) concluded that although perceptual organisation of facial features into a gestalt (Vuilleumier, 2000), and analysis of facial features which express emotions (Vuilleumier & Schwartz, 2001) can still occur for stimuli in the contralesional field, this was not necessarily the case for eye gaze. Although eye gaze can orient attention exogenously, it can only do so when it received adequate attention (i.e. when eye-gaze information appeared in the intact ipsilesional hemifield).

A further subset of experiments were carried out by Vuilleumier (2002) to investigate whether eye gaze could orient attention to a specific location in contralesional space in the presence of other targets (see Figure 2).

Figure 2. Examples of stimuli used in Vuilleumier's (2002) target detection experiments, where a central face provides gaze cues to direct attention to target locations. In this example of the 'quadrant' experiment, the central face is displaying a valid 'same location' cue to the target location.

These experiments utilised the classic cued detection paradigm of Posner and colleagues (e.g. Posner et al., 1984; 1987) and consisted of a centrally presented face in which non-predictive gaze was shifted towards one of four possible target locations. As expected, the patients showed faster detection of targets in the ipsilesional, rather than contralesional field, and also made faster responses at long SOAs than at short SOAs. For both hemifields, there was an advantage for target detection when the eye-gaze cue was valid, rather than neutral (i.e. looking straight ahead) or when the eyes were directed towards another location on the same side, as would also be expected from Posner's cue-validity effect (Posner et al., 1984). Also, there was no difference between RTs following neutral gaze and following gaze towards another location on the same side. Vuilleumier (2002) suggested that this indicated that gaze was able to cue attention to a specific location within each hemifield, rather than simply inducing a general bias in attention to one side. Left visual field (contralesional) targets were detected significantly more slowly when eyes were directed towards the opposite side than when they were directed towards a different location on the same side (e.g. when the gaze cues the top left location, but the target appears in the bottom left location), yet there was no such difference between these cues for right visual field (ipsilesional) targets. It appears that the patients had difficulty in disengaging attention from the ipsilesional side once it has been cued there, and hence took longer to detect contralesional targets under these conditions (Vuilleumier, 2002). This result supports the findings of Posner et al. (1984) and thus suggests a deficit of endogenous orienting once attention has been exogenously oriented to the ipsilesional side by centrally presented eye gaze shifts.

The experiment described above was replicated with the same group of parietal-damaged patients, with the exception that the central face/gaze cue was replaced with a directional arrow cue. Interestingly, Vuilleumier (2002) reported no reliable validity effect of arrow direction, indicating that there was no advantage for detection of validly cued targets over those where the arrow pointed towards the incorrect location, or remained in a neural position. However, left sided (contralesional) targets were detected significantly more slowly at long SOAs, when the arrow pointed towards the opposite side, as compared to neutral arrows. Vuilleumier (2002) suggests that the rightward pointing arrows induced some amount of endogenous orienting and slowed the detection of contralesional targets, although there was no effect of the leftward pointing arrows.

Vuilleumier (2002) showed that eye gaze could cue parietal-damaged patients and controls to specific locations on both sides, but that there are no reliable cueing effects with an arrow stimulus, and concluded that gaze cues can induce shifts of attention to specific locations despite parietal damage, and that these shifts represent exogenous orienting. However, there are some limitations in Vuilleumier's (2002) methodology which are detailed and addressed in Chapter 2, where Vuilleumier's (2002) Experiment 4 (eye gaze cues) and Experiment 6 (arrow cues) will be replicated with parietal-damaged patients and age-matched control subjects. Vuilleumier (2002) has claimed that eye gaze in particular can exogenously shift attention to the contralesional side in parietal-damaged patients. To date there is no published research on the effects of human pointing cues on attentional reorienting in parietal-damaged patients. Therefore, the experiments in this thesis will attempt to address this issue and investigate whether human pointing cues direct attention in the same way as human eye gaze, or whether they are processed in much the same way as symbolic arrows.

1.4 Social Cues and Theory of Mind

The term 'autism' consists of a spectrum of neurodevelopmental disorders, typically characterised by problems with social communication (Grice, Halit, Farroni, Baron-Cohen, Bolton & Johnson, 2005). It is beyond the scope of this review to discuss in depth the theories surrounding all deficits associated with autism, and instead the focus will be on specific abnormalities in face and gaze processing. Baron-Cohen (1995) proposed a mind-reading model of social attention, within which we have an 'eye direction detector' (EDD) that is specialised for eye gaze perception. This is linked to the 'shared attention mechanism' (SAM) which allows us to interpret whether two people are attending to the same stimulus in the environment (also known as joint attention), and allows us to interpret where someone else is looking and to orient our own attention accordingly (Driver et al., 1999). Baron-Cohen (1995) identified this joint attention ability as being a critical precursor to the interpretation of another person's mental state. Since eye-gaze detection and gaze following are so important in establishing joint attention, it also has particularly important implications for more complex areas of social perception, such as theory of mind (ToM; Baron-Cohen, 1995). Although Baron-Cohen (1995) identified EDD and SAM as developmental precursors to ToM, the directional causality between these modules is less clear when ToM breaks down in adults. This issue will be returned to in Chapter 4 and in the General Discussion.

Our ability to reason about the mental states of others, such as their beliefs, desires and own knowledge is collectively known as 'theory of mind'. Theory of mind (ToM) is considered to be the means by which we understand and predict the behaviour of other people, and hence engage in effective and appropriate social communication. ToM is usually assessed in children via belief reasoning tasks. These tasks require the knowledge that someone else can hold beliefs that are different to our own (i.e. false beliefs), and is usually assessed by stories in which the protagonist is unaware of a change to a situation. For example, Wimmer & Perner (1983) developed the now well-known test which involves two dolls; Sally who has a basket, and Anne who has a box. Sally puts a marble in her basket and then leaves the room. While she is gone, Anne moves the marble into her box. The participant is then asked where Sally will look for her marble when she returns. The child must infer that Sally still believes that her marble is in the basket (the *false belief*), which is different to their own knowledge that the marble now in the box. Most typically developing 4-5 year old children answer correctly, whereas autistic children tend to fail the task by answering according to their own beliefs (i.e. Sally will look in the box;

Baron-Cohen, Leslie & Frith, 1985). Baron-Cohen et al. (1985) conclude that autistic children fail to interpret mental states of others, and as such fail to display a normal theory of mind.

This false-belief finding has been replicated many times in the developmental literature over the years, but recently Apperly, Samson, Chiavarino and Humphreys (2004) noted that relatively few studies have investigated belief reasoning in adults and particularly how this reasoning breaks down following acquired brain injury. They developed a belief reasoning task which does not place heavy demands on language or executive function, in order to investigate levels of belief reasoning in a group of neuropsychological patients. Using these modified belief reasoning tests Apperly et al. (2004) found that three of the studied patients showed a *pure* belief reasoning deficit, without a concurrent deficit in executive function. Interestingly, all three of these patients had suffered lesions to the left temporo-parietal junction (TPJ), which concurs with activation sites from brain-imaging studies of belief reasoning with normal participants (Saxe & Kanwisher, 2003; Gallagher et al., 2000). Although these imaging studies showed evidence of bilateral TPJ activation, Apperly et al. (2004) demonstrated that unilateral lesions to this area are sufficient to impair belief reasoning. In addition, they claim that the impairments in belief reasoning could not be due to problems in processing low-level social cues since both control and false belief trials required patients to comprehend the same social cues. In a subsequent study, Njomboro, Deb and Humphreys (2008) showed that the belief reasoning deficits in two of the three patients reported by Apperly et al. (2004) were not the product of an impairment in interpreting low-level facial cues, since these patients showed no impairments in the recognition and understanding of facial expressions. However, Njomboro et al. (2008) warn that although the patients may be able to respond to configural cues to interpret facial expressions of emotion (Baudouin & Humphreys, 2006), they could still have a specific deficit in using subtle information about eye gaze to support theory of mind reasoning. The TPJ/STS region has been shown to be involved in the processing of gaze direction (Frith & Frith, 2006), which is a precursor to ToM where we interpret what another person sees and use this to make inferences about what they think. Therefore Njomboro et al. (2008) postulate that whilst areas that are responsible for configural processing of faces (right fusiform gyrus; Yovel & Kanwisher, 2005) may be intact in these patients, there still may be a specific deficit in using eye gaze to support ToM reasoning caused by the damage to the TPJ. Previous gaze-cueing literature (e.g. Driver et al., 1999, see section *1.2 Social Cues and Normal Attention*) supports the notion that rapid and reflexive orienting in response to eye gaze cues in adults occurs without modulation by ToM processes, which by definition occur later in the processing stream than reflexive shifts of covert attention. However, this is contradicted by findings in the developmental literature which claims that gaze following is modulated by ToM in children (Baron-Cohen et al., 1985). Teufel, Alexis, Clayton and Davis (2010) suggest two alternative explanations for this contradiction; either reflexive gaze following is the result of automatisation of associations during development and as such occurs independently of ToM, or adult gaze following is also susceptible to influences from ToM. They designed a study whereby adult participants viewed a model wearing transparent or opaque goggles, and making non-predictive 'head turn' cues to the left or right before a target appeared on one of the sides. The participants were made to believe that they were viewing a live video link to a model in an adjoining room, thus that they were interacting with a real person, to ensure mental-state attribution. Teufel et al. (2010) showed that when participants believed that the model could see (in the transparent goggle condition), the gaze cueing effect was larger than when they believed that the model could not see (i.e. in the opaque goggle condition). Furthermore, even when the gaze cues were counter-predictive (i.e. when the target was more likely to appear at the uncued location), participants were able to voluntarily reorient their attention away from the models gaze direction when they believed the model could not see. However, when they believed that the model could see, participants were unable to voluntarily orient away from the models direction of gaze, thus indicating a reflexive cueing mechanism that was not suppressed by top-down control. Teufel et al. (2010) conclude that ToM processes strongly modulate reflexive shifts of attention in response to another person's eye gaze direction, ensuring efficient and appropriate social orienting. That is, this kind of interaction between higher-order and reflexive functions allows for an attentional system that can ignore gaze cues from somebody who may be looking in a particular location but not necessarily attending to it, and instead orient in response to deeper social cognitive meaning of another person's looking behaviour. Whilst this is an extremely informative finding with regards to the interplay between higher-order mental-state attribution and reflexive orienting in response to gaze cues, Njomboro et al. (2008) urged for further research into gaze following behaviours in patients with acquired ToM deficits. For this reason, social orienting in response to human gaze and pointing cues will be investigated in a patient with a pure belief reasoning deficit in Chapter 4 of this thesis. As yet there has been no research published comparing the relative cueing effects of gaze and pointing cues in patients with acquired ToM deficits, and so the experiments in Chapter 4 will provide an account of the spared and impaired social orienting mechanisms in a patient with a completely impaired ability to interpret another person's beliefs or intentions.

1.5 Social Cues and Autism

In addition to disrupted gaze monitoring in Autism Spectrum Disorder (ASD) and ToM, Baron-Cohen, Cox, Baird, Swettenham, Nightingale, et al. (1996) found that impaired prodeclarative pointing is also a successful predictor of autism in children at 18 months of age. Prodeclarative pointing and gaze monitoring are imperative to social communication as they form the basis for joint attention behaviours that allow infants and adults to attend to the same object or event (Bruner, 1983; Baron-Cohen, 1995). Much of the social cueing literature has focussed upon how autistic individuals orient their own attention in response to another's eye gaze cues, in comparison to how this occurs in typically developing individuals. However, as is the case with parietal-damaged patients, the autism literature has tended to lack in a systematic investigation of how human pointing gestures influence covert attention in typically and atypically developed individuals. Observational research with children has investigated the effects of joint attention to gaze and pointing cues in autistic children (Dawson, Meltzoff, Osterling, Rinaldi & Brown, 1998). Dawson et al. (1998) found that autistic children made significantly more errors in a joint attention experiment than typically developed (TD) children and than children with Down syndrome, but there were two main problems with this research. Firstly, each child (N=20) was only given the opportunity to respond twice for each type of cue (once to targets in front of them and once to targets behind them, each for gaze and pointing cues) which does not provide scope for improvement across trials. Secondly, the analysis was based on error data collapsed across pointing and gaze conditions, which does not allow for any comparison of the relative cueing effects of each gesture in autistic individuals. Later research by Doherty and Anderson (1999) confirmed that TD children are better able to understand pointing gestures than eye gaze gestures, but there has been very little subsequent research into the effect of pointing gestures on the reorienting of *covert* visual attention in autistic individuals. Most studies investigate potential differences between orienting in response to various permutations of gaze and arrow cues, and mostly in ASD children rather than adults. In one such study, Swettenham, Condie, Campbell, Milne and Coleman (2003) investigated the effect of face inversion on gaze cueing in autistic children. They reported evidence of reflexive orienting in response to upright and inverted gaze cues across the ASD and TD groups, with significant cue-validity effects observed after an SOA of 100ms in both groups. They explain that autistic children tend to favour the processing of individual features over global properties of visual stimuli (Frith, 1989), which explains why inversion does not affect performance in the ASD group. Previous studies (Leekam et al., 1997; 2000) showed that autistic children were unable to make use of a gaze cue in the same way as TD children (faster target detection following valid than invalid gaze cues) but Swettenham et al. (2003) propose that this is due to differences in the age groups of the recruited autistic children. According to Swettenham et al. (2003) a delay in the development of the reflexive orienting response in autism, would explain why their autistic participant group (aged 10yrs) showed 'normal' orienting to gaze cues when Leekam et al.'s group (aged 4yrs) did not. Here Swettenham et al. (2003) point out that young children look less at other people than do TD children (Swettenham et al., 1999), hence limiting their experience with gaze following, which may delay the learning of this normally reflexive response until later in development. This is consistent with the hypothesis that reflexive orienting in response to gaze cueing is the result of an over-learned association, (see Vecera and Rizzo, 2004) and shows that at least some exogenous orienting mechanisms are intact in autism. Although the children (both ASD and TD) showed no effects of face inversion on gaze cueing, in normal adult participants, face inversion has been shown to disrupt gaze cueing (Langton & Bruce, 1999). This could be due to methodological differences. In the studies with children (e.g. Swettenham et al., 2003) there was a subtle gaze shift while that face remained still. Langton and Bruce (1999), on the other hand, depicted an entire head movement from frontal to profile view. In the latter case the 'global' head served as the directional cue, whereas in the former case the 'local' eyes were the cue of interest. Therefore it is not surprising that the cues in Langton and Bruce's experiment were subject to interference from inversion, as the cue in itself demanded configural processing, which is disrupted by inversion (Yin, 1969) and autistic individuals favour local over global processing (Frith, 1989). However, the question remains whether ASD adults would show the same effects of face orientation on gaze cueing as ASD children (i.e. no effect of inversion), or the same effect as TD adults (i.e. a disruption to gaze cueing following face inversion).

A more recent study by Greene, Colich, Iacoboni, Zaidel, Bookheimer and Dapretto (2011) investigated covert social orienting to gaze cues in TD and ASD children, in simple laboratory experiments and in a brain imaging experiment. They showed that in behavioural experiments, TD and ASD children showed similar effects of social orienting in response to gaze cues in relation to arrow cues, where both groups showed evidence of standard validity effects in response to both types of cue. In addition, both groups of children showed significantly faster reaction times in response to gaze cues than to arrows. However, in the functional magnetic resonance imaging (fMRI) experiment, the brain activity was very different between the typically developing and the ASD children. The TD group showed greater activity in response to social cues than non-social cues in fronto-parietal regions associated with spatial orienting, and in the anterior cingulate which is associated with executive attention. However, the ASD group only showed increased activity in response to social over non-social cues in the superior parietal lobule and in visual association cortices. The most relevant finding from Greene et al.'s (2011) research to this thesis is that TD and ASD children can show the same behavioural responses to social and non-social stimuli, although the neural circuitry involved is vastly different. Nation and Penny (2008) offer the explanation that ASD children process gaze cues as non-social cues, using non-social mechanisms that make use of the low level directional properties of eye gaze shifts rather than on the social significance of the cue. However, Rutherford and Krysko (2008) showed that in a group of autistic *adults*, low-level directional motion did not account for cueing effects of gaze. Participants were presented with face cues in which gaze was shifted to the left or right, or where the pupils remained in the same position and the face was shifted laterally. In this latter condition, terminal eye gaze and direction of motion were opposing, but both ASD and TD adults showed stronger cueing effects in response to the valid gaze direction, rather than the direction of lateral face movement. This effect was apparent after a 100ms SOA, which is suggestive of reflexive orienting in both groups. Rutherford and Krysko (2008) highlight that models of social orienting (e.g. Baron-Cohen, 1995; Baron-Cohen et al, 1996) in autism are based on children, and that their research shows that deficits in eye gaze following actually improve with age in ASD (see also Webster & Potter, 2008). It is therefore important for more research to be carried out with ASD individuals of adult age, so understanding of the development of social orienting into adulthood can be increased. Furthermore, the incorporation of pointing gestures into these cueing paradigms may help to answer the question of whether gaze is ‘special’ in terms of its social relevance and effect on ‘reflexive’ attentional reorienting.

One line of research has suggested that the study of cognitive processes in typically developed adults who display higher than average autistic personality traits can shed light on the deficits in autism, without the confounds of impairments to language and IQ which are inherent in autistic individuals (Stewart, Watson, Allcock and Yaqoob, 2009). Baron-Cohen, Wheelwright, Skinner, Martin and Clubley (2001a) developed a self-report questionnaire called the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001a), to assess the extent to which adults of normal IQ share traits with autistic individuals. The 50-item questionnaire is divided into five subscales which measure social skills (e.g. I prefer to do things with others rather than on my own), communication (e.g. I enjoy social chit-chat), imagination (e.g. I find making up stories easy), attention to detail (e.g. I often notice small sounds when others do not) and attention switching (e.g. I prefer to do things the same way over and over again), where each subscale is assessed by 10 questions each. There are four possible responses to each question (definitely agree, slightly agree, slightly disagree, definitely disagree) which were scored with either 1 or 0 depending on whether the question is worded to elicit an 'agree' or a 'disagree' response, eliciting a potential range of scores between 0 and 50. The resulting score is the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001a), where a high score indicates a high level of traits shared with ASD individuals, and a low score indicates a low level of traits shared with ASD individuals. Initial studies from UK samples have showed a satisfactory level of reliability for the AQ and its subscales (Austin, 2005; Baron-Cohen et al., 2001b), and research has shown high levels of heritability of autistic traits (Hoekstra et al., 2007). Psychological research has shown that autistic-type traits in typically developed adults can predict performance on cognitive tasks, such as the block design task (Stewart, Watson, Allcock and Yaqoob, 2009).

More specifically to our topic of interest (i.e. social orienting) Bayliss and Tipper (2005) used the AQ to divide normally developing participants into high- and low-scoring groups in terms of autistic traits, and found differences between the groups in a gaze cueing task. Participants could be cued by a central gaze or arrow cue, towards a peripheral target that could appear on either a face or a scrambled face. Although both groups were cued with equal magnitude by the central gaze shifts and arrows, Bayliss and Tipper (2005) found that the low AQ group showed greater cueing to targets that appeared on faces, whereas the high AQ group showed greater cueing to targets appearing on scrambled faces. These effects were due to the target properties and not cue properties, as there was no significant effect of cue type. Therefore, when observing an interaction between the cue and target, there was no difference in the cue-validity effect whether the cue and target were both faces, or if a face target was cued by a central arrow. Again, this finding lends support to studies discussed in previous sections of this review which have shown no difference in the cueing effects of gaze and arrows in normal observers (Tipples, 2002; Ristic et al., 2002). Although there was no overall effect of AQ group, Bayliss and Tipper (2005) did find differences in high and low scoring AQ participants between orienting *towards* social and non-social (scrambled objects) stimuli, and is hence slightly different to orienting attention in response to such stimuli when it acts as a central cue to attention. That is, in this case attention, is being *engaged* in a different way according to the type of stimulus at the target location, rather than being *reoriented* by the stimulus in the centre of vision. As such, Bayliss and Tipper's (2005) study is highlighting effects which occur at different stages of attentional orienting than other studies reviewed in this Chapter (please refer to Posner's work in section *1.1 The Posner Cueing Paradigm* for a review). Nevertheless, this finding has demonstrated that greater cueing towards faces only occurs in individuals from the general population who have a cognitive style that is biased towards the processing of social information. That is, people who score low on the AQ show a bias towards socially relevant stimuli, whereas people who score high on the AQ show a bias towards non-social or mechanical stimuli. This is consistent with accounts of the processing styles which are characteristic of ASD. Happé and colleagues (Happé, 1997; Happé, Briskman & Frith, 2001; Happé & Frith, 2006) put forward the 'weak central coherence' whereby individuals with ASD display a perceptual bias towards local processing, to the detriment of processing global form. They suggest that rather than *explaining* deficits in social cognition that are inherent in ASD (i.e. ToM), weak central coherence may occur alongside these as a general cognitive style. Baron-Cohen (2002) agrees that there is a local processing bias inherent in ASD, but that this reflects to strong tendency to '*systemise'* (i.e. to understand and build systems) in this group of individuals. This tendency is assessed in the AQ, and as such is linked to diversity in cognitive style in the normal population, rather than to those formally diagnosed with ASD.

Since ASD is assumed to lie along a continuum, it will be interesting to investigate differences in performance of normally developed adults who display higher than average autistic personality traits. Indeed, Bayliss and Tipper (2005) have shown different processing styles of socially relevant stimuli in normal participants who share a high or low number of traits with the ASD population. As with previously discussed literature surrounding social orienting, there has been no published work to date on how such individuals may differ in terms of processing human pointing cues. The final empirical Chapter of this thesis will investigate differences in orienting in response to eye gaze, human pointing and arrow cues, in a group of non-clinical individuals who show lower or higher than average scores on the AQ (Baron-Cohen et al., 2001; see Chapter 5).

1.6 Aim and Overview of the Thesis

The studies in this thesis are based upon the design and methodology of Vuilleumier's (2002) 'quadrant' experiment (see Vuilleumier, 2002; Experiment 4) which investigated whether eye gaze and arrow cues could direct attention to specific target locations within each visual field. However, Vuilleumier's findings were based upon a very small data set, using liberal statistics to assess differences in reaction times between conditions. The first empirical Chapter in this thesis will attempt to replicate Vuilleumier's findings in a larger dataset from a group of parietal-damaged patients and more appropriately age-matched controls, using more stringent statistical methods to investigate differences between the conditions. It is predicted that the results from the upright gaze and arrow cueing experiments will be very similar to those of Vuilleumier (2002; see section *1.3 Social Cues and Brain-Damaged Patients*), but will be based on a much larger dataset and so will confirm the reliability of his findings. To further the research of Vuilleumier, the experiments in this thesis will not only use arrows as a comparative stimulus to the gaze cue, but also compare the cueing effects of inverted gaze cues, and upright and inverted human pointing cues. Research findings with normal participants (Langton & Bruce, 1999) and split-brain patients (Kingstone et al., 2000) have shown that inverting the central gaze cue in target detection experiments disrupts the cue-validity effects found with upright gaze cues. However, there is no literature at present which investigates this gaze-inversion effect in parietal-damaged patients, and so this forms the basis for one of the research questions of this thesis (see Chapters 2 & 3). Given that cueing is disrupted by gaze inversion in normal viewers, and that face and gaze cues are processed in temporal areas (fusiform gyrus, STS), it is not expected that gaze inversion will have an effect on cue-validity in the parietal damaged patients or control group. However, since parietal damage disrupts spatial orienting more generally, it is prudent to test whether inverted gaze cues can still cue attention to the neglected side (cf. Vuilleumier, 2002) albeit a potentially attenuated effect in relation to upright cues (Langton & Bruce, 1999). With respect to pointing cues, it is unclear whether they will produce the same effects as eye gaze cues with the parietal damaged group in Vuilleumier's (2002) experiment (i.e. reflexive location-specific cueing effects), or similar effects to arrow cues in this group (i.e. no reliable cueing effect in either direction). If pointing is processed and attended to as a socially and biologically relevant cue like eye gaze, then we would expect similar results from these two cues, i.e. reflexive location-specific cueing effects. However, if the pointing gesture is more symbolic in nature then we would expect similar results as with arrow cues, and this would add support to Vuilleumier's (2002) claim that eye gaze has a special and unique influence on attentional reorienting in terms of its social relevance. Further to this, if the pointing figure is processed configurally as a social cue, then we would expect inversion to disrupt the cueing effect as with gaze cues (cf. Langton & Bruce, 1999). However, if the pointing arm is processed as a symbolic cue (like an arrow) that is separate from the human body in terms of social significance, then we would not expect any effect of inversion on cue-validity.

Chapter 3 will address the same research questions in a larger group of parietal damaged patients in experiments which incorporate more realistic central cues, as Smilek et al. (2006) and Greene et al. (2010) have urged that more ecologically valid stimuli be used in laboratory experiments designed to investigate social orienting. Furthermore, the use of realistic images allowed for the development of a more subtle pointing gesture cue, which would allow investigation of social cueing effects without the confounds of proximity and motion which may have been present in the case of schematic pointing cues. These experiments using more realistic gaze and pointing cues will also be carried out with a patient who presents with a ToM deficit (Chapter 4), and a group of non-clinical participants who display 'autistic-type' personality traits (Chapter 5). Research with brain-damaged patients (Kingstone et al., 2000), ASD children (Swettenham et al., 2003) and normal observers (Langton & Bruce, 1999) have shown differing effects of inverting a central gaze cue (see Tipples, 2005), but there have been no studies into the effects of inversion on pointing cues across such groups. These issues will be addressed by experiments in this thesis. Recent literature has shown that adults who score high or low relative to the mean on the AQ (Baron-Cohen et al., 1996) perform differently on cognitive tasks (Stewart et al., 2009) and in social orienting paradigms (Bayliss and Tipper, 2005). Therefore using the AQ as a selection tool provides us with an accessible population of participants (i.e. normal adults who score within the higher or lower boundaries of the AQ), who may show differences in performance akin to ASD. There is very little research into the effect of pointing cues across the literature, as previously discussed within this review, and so the validity effect of the pointing cue will be assessed alongside standard gaze and arrow cues in a group of normal participants who show high scores on the AQ, which will allow us to draw inferences about the use of these cues in individuals with ASD (see Chapter 5). In addition, the same experiments were carried out in a case-study of a patient with an acquired theory of mind deficit. Teufel et al. (2010) showed that mental-state attribution greatly modulated the gaze validity effect in normal participants, so it was expected that absence of ToM would greatly diminish the standard gaze-cueing effect in this patient. It was surmised that adults who show ASD traits may have learned over time to attend to socially relevant cues, whereas an individual with an acquired ToM deficit may have lost the ability to orient in response to social cues which was present premorbidly. Therefore, in Chapter 5 the high-scoring AQ participants may show a standard cueing effect in response to the gaze, pointing and arrow cues, albeit with a reduced magnitude to that of controls in the gaze conditions, and possibly the pointing conditions. Conversely in Chapter 4, for the ToM patient we would not expect any cueing effect in response to gaze cues, nor to pointing cues if these rely on a 'social' orienting mechanism, but a reliable cueing effect in response to symbolic arrows as shown with normal controls (Tipples, 2002).

Overall, the experiments in this thesis will utilise a well-established paradigm to compare the cueing effects of social and symbolic cues. Very little research has investigated the extent of the cue-validity effects of human pointing gestures, and whether these effects are disrupted by inversion (as shown in some groups for gaze cueing). Such manipulations and comparisons between these types of cues can help us to answer the question of whether gaze really is ‘special’ in its automatic orienting effects on attention, or if pointing cues also constitute a socially significant cue which is attended to reflexively. Furthermore, the effects of different types of social and symbolic cues (gaze, pointing and arrows) are investigated in three distinct populations to explore how attentional reorienting in response to each type of cue is affected by parietal damage (Chapters 2 & 3), an acquired ToM deficit (Chapter 4), and a cognitive style that is associated with ASD (Chapter 5). This will shed light on how social cognition is affected by different neuropsychological disorders, and in turn will allow us to make inferences about social networks in the brain. It is hoped that the findings can be used to inform strategies for rehabilitation in visual neglect, and social cue following in autism.

CHAPTER 2:

THE EFFECT OF SCHEMATIC SOCIAL CUES ON THE REORIENTING OF VISUAL ATTENTION IN PARIETAL-DAMAGED PATIENTS AND AGE-MATCHED CONTROLS

2.1 Introduction

Are all schematic social cues influential in reorienting the attention of parietal-damaged patients, or is eye gaze really special in this respect? The experiments in this Chapter will attempt to replicate Vuilleumier's (2002) previous findings with schematic eye gaze and arrow cues, and to extend this by investigating the cueing effects of schematic pointing gestures. Vuilleumier (2002) showed that eye gaze could cue both patients and controls to specific locations on both left and right sides of fixation; on the other hand, no reliable cueing effects with a central arrow stimulus were found. Vuilleumier concluded that gaze cues can induce shifts in attention to specific locations despite parietal damage, and that these shifts represent exogenous orienting. Although this was an impressive finding, the data presented are rather limited, for a number of reasons. Firstly, there were only five trials per condition for both the patients and control participants, which is a rather small number of data points upon which to base an overall mean. Following standard data-cleansing methods, five would have been the maximum number of data points remaining in Vuilleumier's (2002) data. A small data set could be a particular problem for patients' data, which is inevitably more variable than control data. The six neurologically intact controls who took part in Vuilleumier's (2002) Experiment 4 were not well age-matched to the three patients, with control age ranging from 34-70yrs and patients' age ranging from 60-68yrs.

In addition, controls were not tested in Vuilleumier's (2002) experiment where arrow cues were used, so it remains unclear whether the failure to demonstrate spatial cueing with arrow cues was due to the nature of the parietal damage, or to the arrow cue itself.

The following experiments aim to rectify the problematic issues outlined above. Vuilleumier's Experiment 4 (eye gaze cues) and Experiment 6 (arrow cues) were replicated with a group of parietal-damaged patients (N=4) and age-matched control subjects (N=7) in the following experiments (Experiments 1 and 3, respectively). As we were limited to the number of parietal-damaged patients we could recruit for this series of experiments (N=4), we compensated for the small sample size by collecting a larger volume of data than Vuilleumier (2002). Where Vuilleumier (2002) based his findings on mean RTs from 5 trials per experimental condition, we calculated a mean RT from 20 trials per condition, and repeated each experiment 4 times with each of the patients. This increased the sensitivity of the data analysis to detect a relatively subtle gaze cueing effect in a small group of participants. In addition, we examined the validity effects of another social cue, namely pointing (Experiment 2). There has been relatively little research into the cueing effects of human pointing gestures, and we propose that this stimulus could be seen as 'bridging the gap' between eye gaze and arrow cues. That is, pointing represents another cue to direct another person's attention, which is human in nature but distinct from eye gaze. People point because they deliberately want a viewer to attend to the target they are pointing to. The pointing cue is not as ambiguous as eye gaze, where the gazer may simply be attending to something that *he* finds interesting, and not something he particularly wants *the viewer* to attend to. It could be that eye gaze requires a theory of mind and shared attention, whereas pointing simply requires a directional shift of attention in much the same way as we respond to symbolic arrows. Alternatively, it may be the case that pointing demands attention in the same way as eye gaze as it is a socially relevant human gesture and associated attentional shifts occur reflexively (cf. Driver et al., 1999). The following experiments intend to assess the independent and relative cueing effects of schematic eye gaze (Experiment 1), schematic pointing cues (Experiment 2) and symbolic arrows (Experiment 3) in parietal-damaged patients and age-matched controls.

In Experiment 1 possible differences in the cueing effects of eye gaze in the context of canonical and inverted schematic faces were investigated. Vuilleumier (2002) concluded that location-specific cueing effects are found with eye gaze and not arrows, but this experiment will utilise the inverted face as a more subtle and better matched control experiment to compare the relative cueing effects of the gaze cue. That is, stating that an upright gaze cue produces reflexive, location-specific cueing effects that are absent with arrow cues may not accurately depict the social nature of the gaze cue itself, but a vast difference in the type of cue. Comparing the effect of an upright versus an inverted gaze cue will allow us to compare the relative cueing effects of a purely social cue (upright face) with a cue of the same size, proportion, level of detail, etc. which may not be processed as a socially salient cue (inverted face). Langton and Bruce (1999; see section *1.2 Social Cues and Normal Attention* of Literature Review) found that neurologically intact participants show a decline in validity effects when the central gaze cue is inverted as opposed to when it is presented in the canonical upright orientation. The differences between the current experiments and those of Langton and Bruce (1999) are that simple, schematic face cues are presented here rather than photographic face cues. Tipples (2005) has shown that in normal observers, there is no effect of inversion of gaze inversion on cue detection, and furthermore that there is no difference between cue validity effects of gaze cues presented within schematic and realistic faces. However, gaze-inversion effects have not yet been explored in parietal-damaged patients in a cued detection paradigm (neither with schematic nor photographic cues). Damage to the parietal lobes typically impairs spatial orienting (e.g. in the form of visual extinction and/or neglect), and Karnath et al. (2003) have shown that visual extinction is associated with lesions to the Temporo-Parietal Junction (TPJ); an area which is also implicated in gaze following and ToM (Saxe & Kanwisher, 2003; Gallagher et al., 2000). Therefore, since gaze meaning is processed via the TPJ (as well as the STS area; Harries & Perrett, 1991), then the extinction patients in our study may not be able to make use of these cues to shift attention to specific locations on the extinguished side when the configural relations between the facial features are lost through inversion (Yin, 1969). Therefore, in the presence of an existing spatial orienting deficit and TPJ damage, the inverted face may not be a successful cue to reorient attention to the extinguished side. Since this has not yet been explored in parietal damaged patients it is prudent to test patients' performance with upright and inverted orientations of gaze (and pointing) cues in the following experiments. Indeed, if the cueing effect associated with the schematic gaze cue is disrupted by inversion, as is the case with photographic faces (cf. Langton & Bruce, 1999) then there should be no reliable cue-validity effects for the inverted gaze cue for neither the controls nor patients. However, if the schematic faces lack the complexity and hence social nature that a photographic face elicits, then we expect there to be no effect of inversion upon cue-validity.

In a second experiment, the effect of human pointing cues on visual attention in parietal damaged patients and age-matched controls (in contrast to the symbolic gaze cues used in Experiment 1) are examined. Again, the orientation of the cue is manipulated to determine whether there are differential validity effects. Inversion effects have been shown with body and face recognition (Reed, Stone, Bozava & Tanaka, 2003), namely that recognition is impaired by inversion of bodies and faces alike. In this respect we may expect to find that the inversion of pointing gestures will limit the effectiveness of the cue to direct our attention. However, Reed et al.'s (2003) research findings are based upon recognition tasks rather than target detection tasks like the ones presented here. According to Slaughter, Stone and Reed (2004) detection refers to the process of determining whether a particular stimulus is a face or a body, and occurs at an early stage of visual processing. Recognition refers to the process of distinguishing between individual faces or bodies, and occurs at a relatively later stage of processing than detection. As with Reed et al. (2003), we should expect to find an inversion effect for our pointing cue (i.e. a disruption to normal cue-validity effects) if the pointing arm is processed as part of the whole body, in a configural manner. However, if the pointing arm is processed independently of the body, as a symbolic directional gesture, then there would not be an effect of inversion of the pointing cue on target detection. Vuilleumier's arrow experiment (Vuilleumier, 2002; "Experiment 6") was replicated here (Experiment 3) although in this instance the effects of location-specific cueing in response to a symbolic arrow in parietal damaged patients was compared with that in neurologically intact controls. Central arrow cues have been shown to induce exogenous shifts of attention in normal observers, suggesting that reflexive cueing is not restricted to biologically relevant stimuli (Tipples, 2002; Ristic et al., 2002). Vuilleumier's (2002) finding that parietal-damaged patients were not cued by a central arrow was based on a limited dataset, and as such seems potentially unreliable given the findings of Tipples (2002) and Ristic et al. (2002). It is hypothesised that with the larger dataset, validity effects of the central arrow cue may be demonstrated in both patients and matched controls. Specifically, the experiments in this chapter aimed to address the following research questions:

1) Are patient and control RTs faster following upright than inverted gaze and pointing cues? Since research has shown similar inversion effects with body and face recognition (Reed,

Stone, Bozava & Tanaka, 2003), then we may expect that gaze and pointing gestures made by inverted faces and bodies do not have the same impact upon our reorienting of attention as do upright faces and bodies, as shown by an attenuation of cueing effects in inverted conditions. Driver et al. (1999) have shown that inversion disrupts gaze-cueing in normal observers, so we will investigate whether this occurs with parietal-damaged patients, and if this inversion effect extends to pointing cues.

2) How do validity effects compare following gaze and pointing cues, and between pointing cues and symbolic arrows? Is it only gaze cues which produce the validity effects following a short (100ms) SOA as Vuilleumier (2002) suggests, or do pointing cues also invoke automatic (exogenous) reorienting of attention when presented in isolation (cf. Langton & Bruce, 2000)?

3) Can parietal-damaged patients detect targets on the contralesional side, even after invalid cueing, and for all of the cues or just for eye gaze?

2.2 Methods

2.2.1 Participants

Four patients JB, MH, PF and RP (2 female; mean age 62.5 years; range 56 – 75 years; SD 8.7) completed 4 runs of each of the 3 experiments. Each run took about 20 minutes to complete, and patients were tested across many sessions depending on their availability, but the 3 experiments were completed in a random order. All patients presented with visual extinction on double simultaneous stimulation after sustaining damage to one or both parietal lobes. MH shows visual extinction of the right-sided item, whereas patients JB, RP and PF extinguish the left-sided item. (Note that patients MH and PF have bilateral parietal damage). Please see Appendix II for further details of patient lesions and demographics.

Seven age-matched control participants (mean age 66.0 years; range 58 – 76 years; SD 6.1) also completed the experiments, although these participants were only tested on one run of each experiment. Each experiment took 15-20 minutes to complete, and controls were tested across two sessions, with the experiments being presented in a random order across participants. These participants had no history of neurological damage and were paid a small fee for their time. Note that the same patients and controls took part in Experiments 1, 2 and 3.

2.2.2 Design

For the experiments reported in this Chapter (and indeed for all of the experiments in this thesis), the design was a replication of Vuilleumier's (2002) Experiments 4 and 6. Each trial would start with a fixation cross for 700ms, followed by a central cue in the neutral position for 800ms. Following this, the central cue could then either cue one of the four empty boxes or remain neutral for a further 100ms or 300ms (variable Stimulus Onset Asynchrony; SOA)[2]. In Experiment 1 the cue would be in the form of a gaze shift (see Figure 3), in Experiment 2 the cue was a pointing gesture (see Figure 6), and in Experiment 3 the cue was a symbolic arrow (see Figure 9). After the variable SOA of 100ms or 300ms, one of the four boxes would be filled in

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[2] These particular SOAs were included so that the study was a direct replication of that of Vullleumier (2002). Although some researchers have failed to find gaze cueing effects at 100ms (e.g. Driver et al., 1999), significant gaze cueing effects were reported after a 100ms SOA by Vuilleumier (2002) in parietal damaged patients, by Brignani et al. (2009) in normal adult observers, and by Swettenham et al. (2003) in ASD and TD individuals. Therefore, we believe that these previous findings from diverse populations justify our use of 100ms and 300ms SOAs throughout the experiments presented in this thesis.

black to become the ‘target’ box. The target and central cue then remained on the screen until a response was made or 3000ms elapsed, whichever came sooner. In all experiments in this thesis, the four equiprobable central cues were non-predictive of target location. Cue conditions were the same as those of Vuilleumier (2002), and the same across all experiments in this thesis. The target could either appear in the ‘Same Location’ as indicated by the cue (valid cueing of the specific correct location on 25% of target trials), on the ‘Same Side’ but different location to that indicated by the cue (invalid cueing of location, but valid cueing to general side on 25% of target trials), on the ‘Opposite Side’ in the mirror location to that indicated by the cue (invalid cueing of the on 25% of target trials), or the cue could remain ‘Neutral’ and the target was equally likely to appear in any of the four locations (no cueing on 25% of target trials). In addition, in each experiment, 50 catch trials were included, where no target appeared and hence no response was required. These were included in an attempt to reduce anticipatory responses and maintain the appropriate level of attention on the task. Each experiment consisted of 320 cued trials and 50 catch trials, giving 20 trials per experimental condition.

The only difference to the design in the experiments presented in this thesis is that the factor ‘Position’ was not included in the analyses, since Vuilleumier (2002) found no effect of whether the target appeared in the upper or lower quadrants, and this manipulation was of peripheral interest to these experiments. A 2 (Orientation: Upright, Inverted) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side) * 2 (SOA: short, long) within-subjects design was employed. Side refers to whether the target appeared on the patients’ ipsilesional or contralesional side, but this factor was not included in analysis of the control data. The short SOA was 100ms in duration, and the long SOA was 300ms in duration.

2.2.3 Procedure

The procedure was the same for each of the experiments presented in this Chapter (and for all experiments in this thesis). Participants and patients sat at a distance of approximately 50cm from the computer screen. Participants were required to press the spacebar on a standard keyboard as soon as they saw a target appear in any of the four locations, and to refrain from responding when no target appeared. On the catch trials where no target appeared participants were instructed to wait for the next trial, which would start automatically after a few seconds. The experimenter carefully watched each participant for the first ten trials to check that fixation was maintained at the centre of the screen, and fixation was monitored periodically. In addition, at each rest break a written instruction appeared on the computer screen to remind the participants to keep their eyes fixated at the centre of the screen at all times.

Experiment 1: Upright vs. Inverted Schematic Eye Gaze Cues

2.2.4 Materials

The central stimulus was constructed following the details provided by Vuilleumier (2002). The face was composed of shapes which were drawn, resized and positioned in Microsoft® Office PowerPoint® 2003. The face outline was circular, and was fitted into a virtual square which measured 5cm². Each of the eyes was oval shaped and measured approximately 1.7cm * 1.1cm, with a 0.8cm² black pupil in each eye. The pupils were manipulated using Adobe® Photoshop® CS2 so that they appeared to look either straight ahead, or towards one of the four target locations. The target boxes measured 1cm² and were positioned 8.5cm from fixation, so that the overall image closely matched Vuilleumier's (2002) original eye gaze stimulus. Examples of each eye gaze direction (cue validity) are given in Figure 3. In the inverted cue experiment, the central image was rotated through 180º so that it appeared to be upside down.

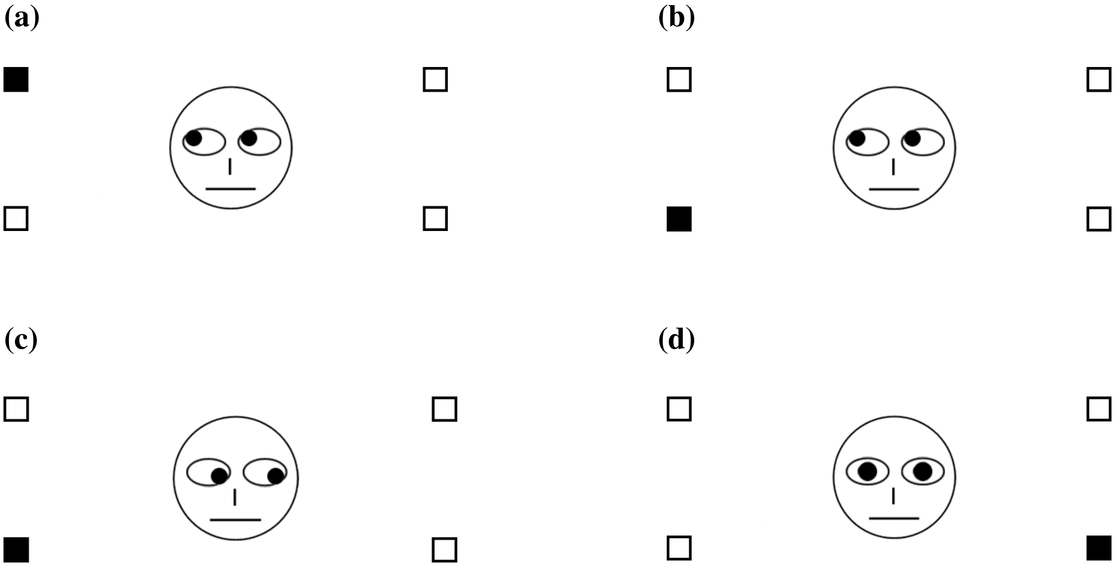

Figure 3. Examples of each cue validity in the upright realistic gaze cue experiment. (a) Same location gaze (valid cue) with the target appearing in the upper left quadrant. (b) Same side gaze (valid predictor of target side, but invalid cue to target location) with target appearing in the lower left location. (c) Opposite side gaze (invalid predictor of target side and target location) with the target appearing in the lower left location. (d) Neutral cue (straight-ahead gaze) with the target appearing in the lower right location.

2.3 Results

The data were analysed for all Experiments in this Chapter (and indeed for all experiments in this thesis) in the same way. All patients completed all Experiments four times, with one cell mean being calculated per patient (by averaging across the mean RTs for each of the four experimental sessions) for the initial analyses comparing patient and control performance, first for patients' ipsilesional target detection and then for contralesional targets. For these analyses the data were entered into a 2 (Group: Patients, Controls) * 2 (Orientation: Upright cue, Inverted cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA for each Experiment. When patient performance was analysed separately, the mean per condition was entered for each of the four experimental sessions, where session was nested within the patient factor. These data were entered into a 4 (Patient: JB, MH, PF, RP) * 2 (Orientation: Upright cue, Inverted cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: short, long) mixed design ANOVA, where Patient was the between subjects factor, with session nested within this factor.

For the Experiment 1, within the patient dataset, misses and anticipatory responses (<100ms) were removed from further analyses (2.62% of total data set). Within the control dataset misses and anticipatory responses were rare but were removed from further analyses (0.04% of total data set). Within each condition for both participant groups, RTs outside of 2 standard deviations (SDs) of the mean were removed (6.47% of total data set for the patient group and 3.47% of total data set for the controls) and a mean RT was calculated from the remaining data for each condition per session of each experiment.

2.3.1 Controls vs. Patients – Ipsilesional Target Detection

The analysis revealed a significant main effect of Group (F (1, 9) = 8.350, p = .018) with controls (387ms) generally responding faster than patients (483ms). There was a reliable main effect of Validity (F (3, 27) = 13.227, p < .001), where Bonferroni-corrected comparisons revealed evidence for location-specific cueing with significantly faster RTs for Same Location (419ms) than Same Side (434ms, *p* = .042). There were no significant differences between RTs for Same Side and Neutral cues (439ms, *p* > .999), which shows that the effect was not one of a general shift to the correct side (see Figure 4). Opposite Side cues (447ms) elicited significantly slower RTs than Same Location (*p* = .002) and Same Side (*p* = .001) cues, but not Neutral cues (*p* = .456) There was no interaction between Validity and SOA, which shows that the location-specific cueing effect was present after both the short and the long SOA, which is indicative of reflexive orienting (cf. Vuilleumier (2002).

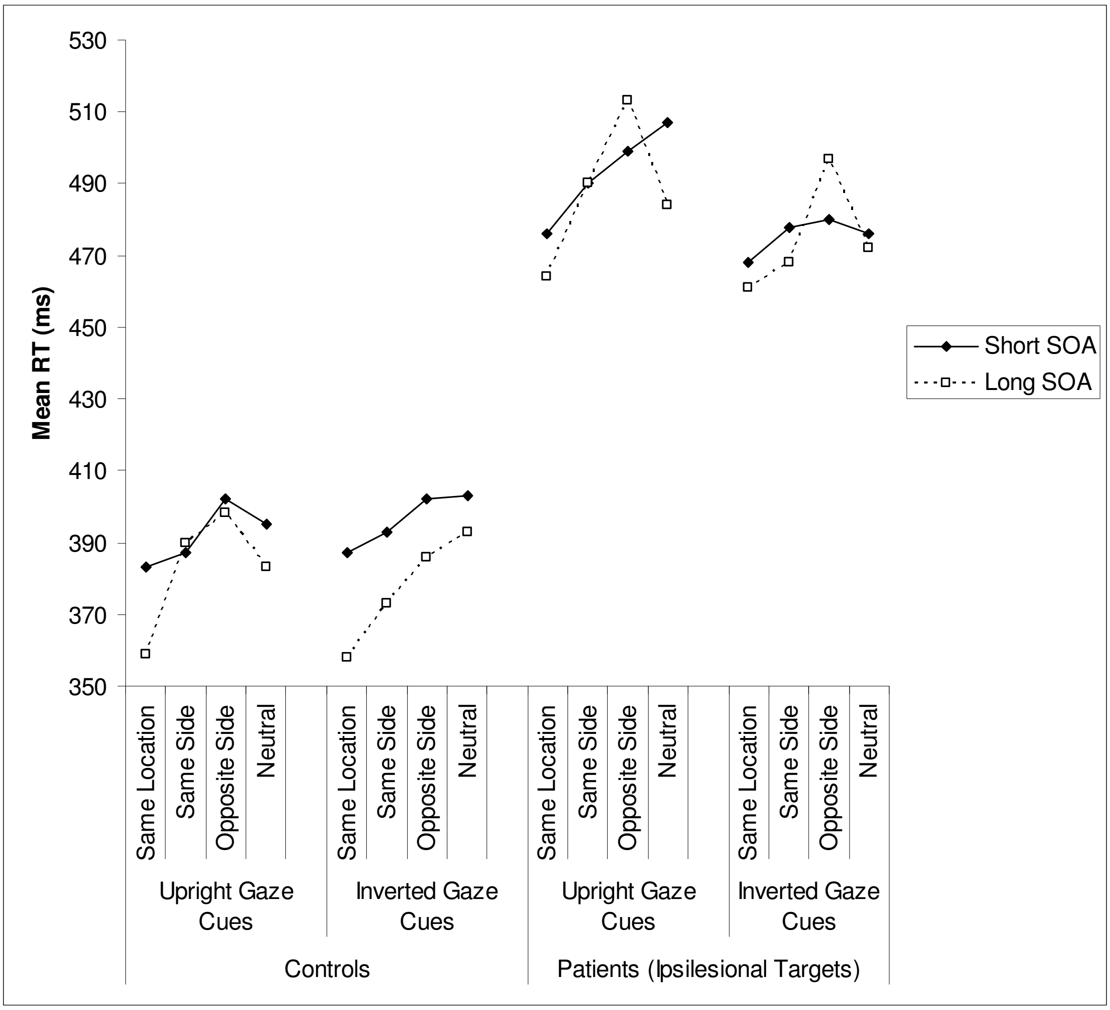

Figure 4. Illustration of Validity effects at both SOAs for the Control group and Patient group (for ipsilesional target detection) in the Upright and Inverted schematic gaze cue experiments.

2.3.2 Controls vs. Patients – Contralesional Target Detection

The analysis revealed a significant main effect of Group (*F* (1, 9) = 14.720, *p* = .004) with controls (387ms) responding much faster than patients (525ms). There were also significant main effects of Validity (*F* (3, 27) = 8.178, *p* < .001) and SOA (*F* (1, 9) = 6.864, *p* = .028, short 462ms, long 449ms) which were qualified by a significant three-way interaction between Group, Validity and SOA (*F* (3, 27) = 3.133, *p* = .042). Separate 4 (Validity) * 2 (SOA) within subjects ANOVAs were run for each group (patients and controls) to decompose this interaction (see Figure 5). The patients showed no significant effects of Validity (*p* > .241), SOA (*p* > .244) or interaction (*p* > .167). However, the age-matched controls showed main effects of Validity (*F* (1.3, 7.6) = 14.633, *p* = .004) and SOA (*F* (1, 6) = 5.821, *p* = .050, short 394ms, long 380ms) but no interaction (*p* > .139). Bonferroni-corrected comparisons between validity conditions showed evidence of location-specific cueing in the control group, with faster RTs following Same Location (372ms) than Same Side (386ms, *p* = .016) cues, and no significant RT advantage for Same Side cues over Neutral cues (394ms, *p* = .723). Since there was no interaction between Validity and SOA, these location-specific cueing effects were evident at both the short and long SOA, consistent with reflexive orienting. However, the patients show no effect of validity in orienting towards contralesional targets, which is inconsistent with the findings of Vuilleumier (2002).

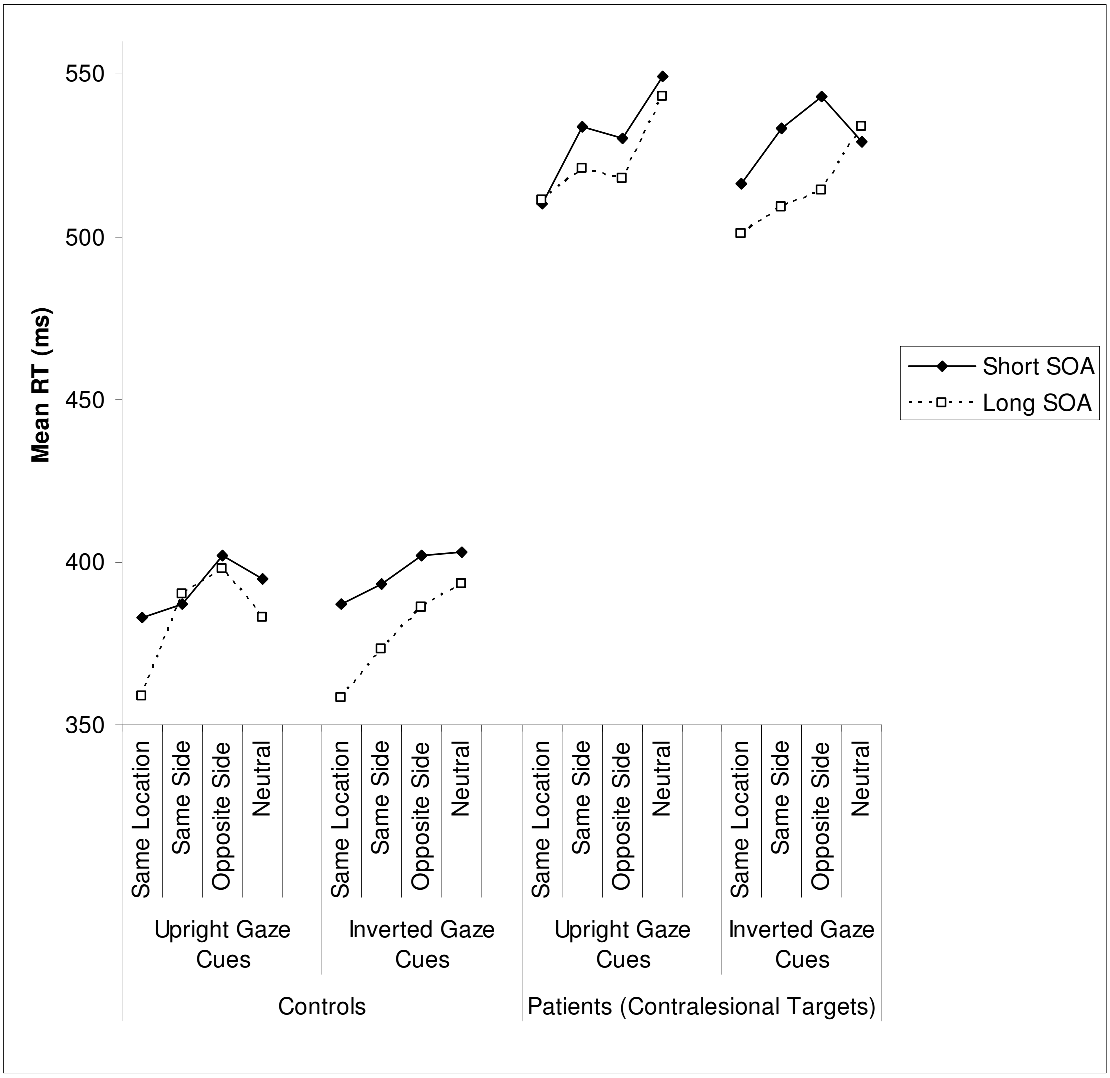

Figure 5. Illustration of Validity effects at both SOAs for the Control group and Patient group (for contralesional target detection) in the Upright and Inverted schematic gaze cue experiments.

2.3.3 Parietal-Damaged Patients

The analysis showed a significant main effect of Patient (F (3, 12) = 64.956, p < .001) which interacted with all other factors (see Table 1 for details)[3]. However, there were some interactions

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[3] Since we are interested in how the patients perform as a group, and in the interest of brevity, the patient interactions will not be decomposed further for any experiments within this thesis. The only interactions to be decomposed are those which are constant across the patients as a group.

between the experimental factors which were not influenced by the patient factor, and hence were constant across the patient group. These interactions were between Orientation and Side (*F* (1, 12) = 6.452, p = .026) and between Validity, Side and SOA (*F* (3, 36) = 3.859, p = .017). These will be decomposed in turn below.

Table 1. A summary of all significant interactions involving the patient factor from the 4 (Patient: JB, MH, PF, RP) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: short, long) mixed design ANOVA for the upright and inverted schematic gaze cues.

Factors	Statistical Result
Validity * Patient	*F* (9, 36) = 7.561, p < .001
Side * Patient	*F* (3, 12) = 159.644, p < .001
SOA * Patient	*F* (3, 12) = 9.089, p = .002
Validity * SOA * Patient	*F* (9, 36) = 3.066, p = .008
Orientation * Validity * Patient	*F* (9, 36) = 2.441, p = .028
Orientation * Validity * Side * Patient	*F* (9, 36) = 3.470, p = .004

Bonferroni-corrected comparisons between the target Side at each Orientation showed that ipsilesional targets were detected significantly faster than contralesional targets at for the gaze cues in both upright (MD 37ms, p < .001) and inverted (MD 47ms, p < .001) orientations. There was no effect of Orientation for either target Side (both *p*s > .337), so it seems that the interaction was driven by a slightly stronger effect of Side for the Inverted gaze cues than the Upright gaze cues.

The Validity by Side by SOA interaction was decomposed by separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) within-subjects ANOVAs for each Side, to investigate the Validity effects in relation to ipsilesional and contralesional target detection. For *ipsilesional* targets, the analysis revealed a significant main effect of Validity (F (3, 45) = 6.765, p = .001) and a significant interaction between Validity and SOA (F (3, 45) = 3.653, p = .019). Bonferroni-corrected comparisons between the Validity conditions at the short SOA showed no significant differences in RTs between any conditions (all ps > .382). At the long SOA, Bonferroni-corrected comparisons showed that RTs in the Opposite Side (505ms) condition were significantly slower than RTs in all other Validity conditions (Same Location 462ms, p = .003; Same Side 479ms, p = .019; Neutral 478ms, p = .016) although no other differences between conditions approached significance (all other ps > .336). This pattern of RTs across the Validity conditions is consistent with a disengage deficit. For *contralesional* targets, the analysis showed significant main effects of Validity (F (3, 45) = 5.109, p = .004) and SOA (F (1, 15) = 5.964, p = .027; short 530ms, long 519ms), but no interaction (p = .175). Bonferroni-corrected comparisons between the Validity conditions showed that the only significant difference in RTs was between the Same Location (509ms) and Neutral (539ms, p = .028) conditions, and no other differences approached significance (Same Side 524ms, Opposite Side 526, all ps > .193). Therefore, there was some effect of valid gaze cueing in relation to straight ahead gaze at both the short and long SOA, but this effect was not location-specific.

2.4 Discussion

This series of experiments were carried out to validate the findings of Vuilleumier (2002) with similar schematic gaze cues in a larger dataset, and also to investigate the effects of inverted gaze cues on target detection. For ipsilesional target detection both controls and patients showed evidence of location-specific cueing across SOAs which is indicative of location-specific cueing effects and consistent with the findings of Vuilleumier (2002) for both patients and controls. This confirms that Vuilleumier's (2002) paradigm is a valid and reliable measure of location-specific cueing effects of eye gaze cues at least, and has thus provided us with a useful paradigm for testing the cue validity effects of other social gestures.

The gaze cueing effect for contralesional target detection in the patient group was limited to a general shift in attention to the correct location relative to neutral cues. This effect was apparent after the shorter SOA of 100ms, which is indicative of reflexive orienting although there was only a 'benefit' of valid cueing relative to neutral cues, but no 'cost' of invalid cueing. This effect was also reported by Friesen and Kingstone (1998), who state that straight ahead gaze may not be strictly 'neutral', in that it can hold attention at fixation in much the same way as it can elicit attentional shifts when averted (Kleinke, 1986). Since there was no significant selective advantage for 'Same Location' cues over 'Same Side' or 'Opposite Side' cues, it must be concluded that gaze shifts were not a reliable cue to reorient attention to the contralesional side in this group of patients. This is contrary to the findings of Vuilleumier (2002) who found location-specific cueing to both contralesional and ipsilesional targets in response to schematic gaze cues. The original idea behind this experiment was to replicate Vuilleumier's (2002) findings based on a larger raw data set per patient (since only four patients were available to complete the experiments). It is likely that the relatively small number of patients showing different magnitudes of effect of target side (as shown by the Patient by Side interaction in the main analysis), increased the between-subjects variance which precluded the emergence of a strong cueing effect. That is some patients were more impaired than others at contralesional target detection more generally, and as such the cueing effect may have been more subtle in these patients. This is one limitation of combining patients in one group rather than carrying out case-studies, but nevertheless shows how they perform overall as a group in relation to normal controls, and thus how parietal damage disrupts attentional reorienting in response to eye gaze shifts.

The analyses revealed no effect of inversion of the central gaze cue in either the parietal damaged group or for the controls, which is consistent with findings from autistic children (Swettenham et al., 2003) and from normal observers (Tipples, 2005). Chapter 3 will verify whether this (lack of) effect remains when more realistic gaze cues are presented to the parietal patients.

Experiment 2: Upright vs. Inverted Schematic Pointing Cues

2.5.1 Materials

This experiment closely followed the paradigm used by Vuilleumier (2002; Experiment 4) with the exception that different cueing stimuli were used. In the current experiment, the central stimulus consisted of a Screen Bean® (http://www.bitbetter.com/screenbeans.htm) at the centre of the computer screen (5cm²), surrounded by four empty boxes (1cm²; 8.5cm from fixation). The original Screen Bean® was manipulated so that it appeared to be pointing towards each target location (reminiscent of the averted gaze in Experiment 1), or remained in a neutral stance (like the neutral ‘straight ahead’ gaze in Experiment 1). The pointing gesture was depicted by one outstretched arm and pointing index finger with the opposite arm bent as if resting on the hip, and the neutral stance showed both arms bent inwards as if the hands were resting on the hips (see Figure 6). In the inverted cue experiment, the central image was rotated through 180º so that it appeared to be upside down.

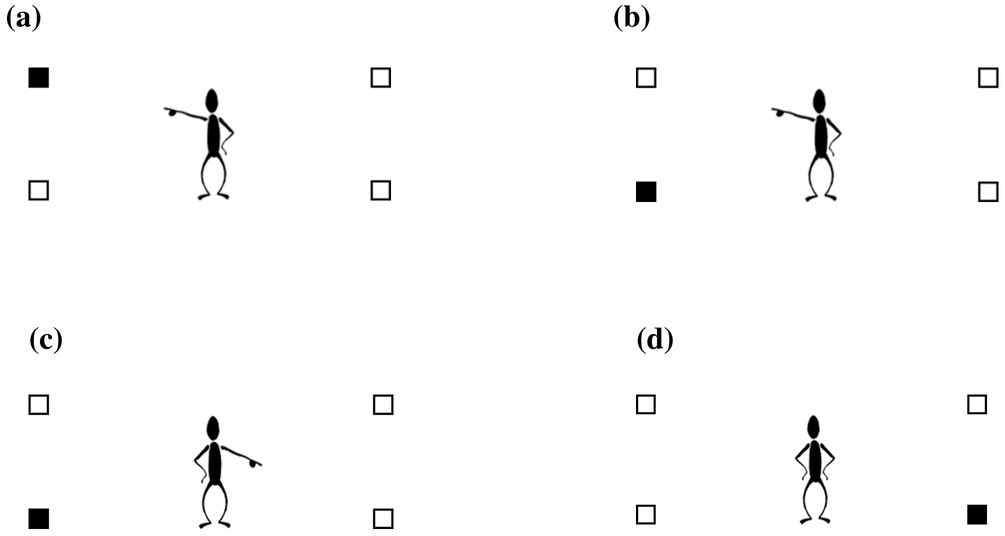

Figure 6. Examples of the validity conditions in the upright schematic pointing cue experiment. (a) Same location point (valid cue) with the target appearing in the upper left quadrant. (b) Same side point (valid predictor of target field, but invalid cue to target location) with target appearing in the lower left location. (c) Opposite field point (invalid predictor of target field and target location) with the target appearing in the lower left location. (d) Neutral cue (with no pointing gesture) with the target appearing in the lower right location.

<u>2.6 Results</u>

Within the patient dataset misses and anticipatory responses (<100ms) were removed from further analyses (3.17% of total data set). Within each condition per patient, RTs outside of 2 standard deviations (SDs) of the mean were removed (5.82% of total data set) and a mean RT was calculated from the remaining data for each condition per session of each experiment. Within the control dataset misses and anticipatory responses (<100ms) were rare but were removed from further analyses (0.05% of total data set). Within each condition per patient, RTs outside of 2 standard deviations (SDs) of the mean were removed (4.21% of total data set) and a mean RT was calculated from the remaining data for each condition.

2.6.1 Controls vs. Patients – Ipsilesional Target Detection

The analysis revealed a significant main effect of Group (F (1, 9) = 7.044, p = .026) with controls (400ms) generally responding faster than patients (493ms). There was a significant main effect of Validity (F (3, 27) = 28.389, p < .001), where Bonferroni-corrected comparisons showed location-specific cueing effects with Same Location (423ms) cues eliciting significantly faster RTs than Same Side (441ms, p < .001) cues. In fact, there were significant differences in RTs between all validity conditions (p < .028) except for the difference between Opposite Side (459ms) and Neutral cues (462ms) which did not approach significance (p > .999; see Figure 7).

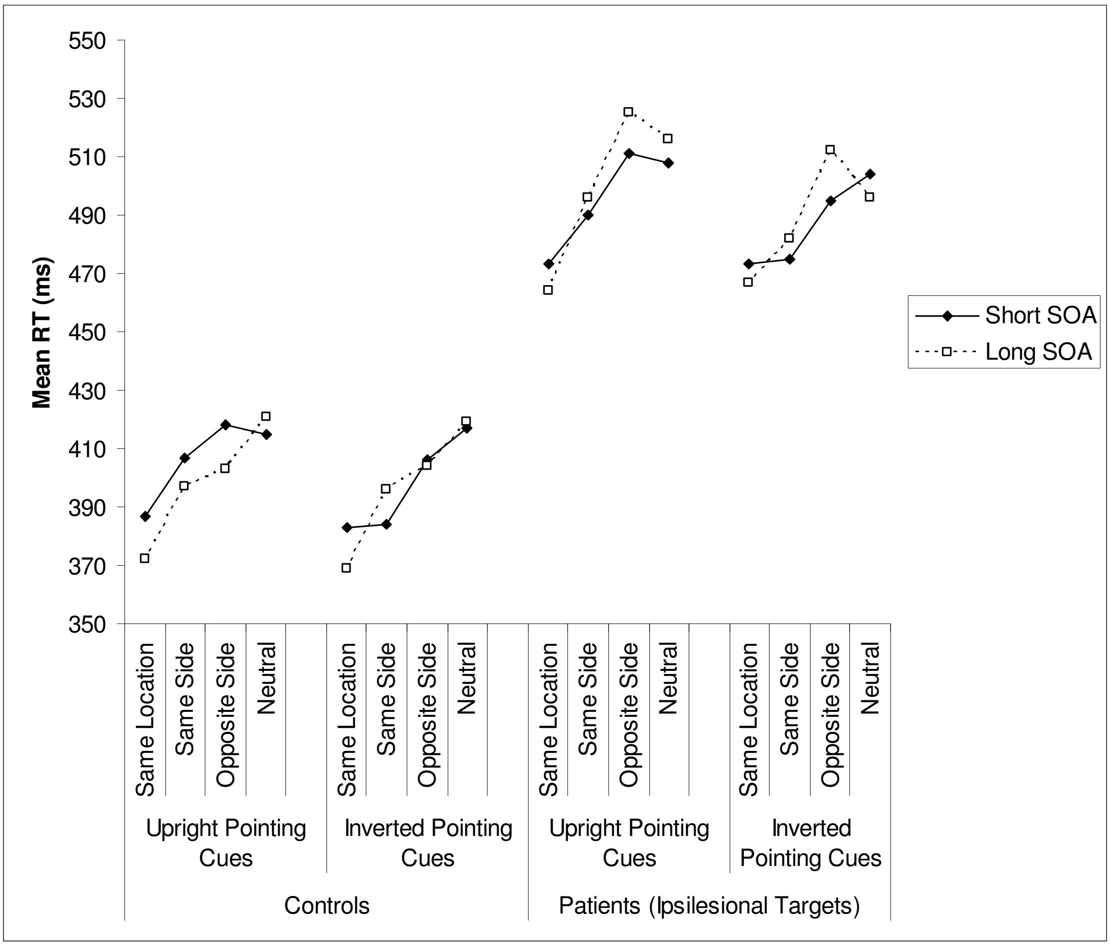

Figure 7. Illustration of Validity effects at both SOAs for the Control group and Patient group (for ipsilesional target detection) in the Upright and Inverted pointing cue experiments.

2.6.2 Controls vs. Patients – Contralesional Target Detection

The analysis showed a significant main effect of Group (*F* (1, 9) = 13.032, *p* = .006) with controls (400ms) responding much faster than patients (532ms). There was a significant main effect of Validity (*F* (3, 27) = 19.456, *p* < .001), and a significant interaction between Orientation, Validity and SOA (*F* (3, 27) = 3.131, *p* = .042). This interaction was decomposed by separate 2 (Orientation: Upright Point, Inverted Point) * 4 (Validity: Same Location, Same

Side, Opposite Side, Neutral) within-subjects ANOVAs for each SOA (short, long; see Figure 8). For the both the short and the long SOA there were significant main effects of Validity (Short: *F* (3, 30) = 11.716, *p* < .001; Long: *F* (3, 30) = 13.376, *p* < .001) but not effects of Orientation or Validity by Orientation interactions (all *p*s > .102). However, the interaction seems to be driven by the different pattern of validity effects between the two SOAs. Bonferroni-corrected comparisons between the Validity conditions at the *short* SOA show no significant difference in RTs between Same Location (431ms) and Same Side (423ms, *p* = .146) cues, which suggests that there was no location-specific cueing effect at the short SOA. However, both Same Location (431ms) and Same Side (423ms) cues elicited significantly faster RTs than Opposite Side (461ms, both *p*s < .002) and Neutral (464ms, both *p*s < .009) cues, which is consistent with a general shift of attention to the correct side in response to the cue. However, Bonferroni-corrected comparisons between the Validity conditions following the *long* SOA show evidence of location-specific cueing effects, where RTs in the Same Location (418ms) condition were significantly faster than RTs in the Same Side (444ms, *p* = .014) condition. To further support this effect, there was no RT benefit of the Same Side (444ms) cue over the Neutral (455ms, *p* = .133) cue, which shows that the cueing effect was not of a general shift in attention to the correct side, but to a specific location within the hemifield.

2.6.3 Parietal-Damaged Patients

There was a significant main effect of Patient (*F* (3, 12) = 35.478, *p* < .001) which interacted with all other factors except Orientation (see Table 2 for details). The only statistically significant interaction which did not involve the Patient factor was between Orientation, Validity and SOA (*F* (3, 36) = 3.444, *p* = .027), and hence this interaction was consistent across the patient group.

This three-way interaction was decomposed by separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) within-subjects ANOVAs for each Orientation. For the *upright* pointing cues there was a significant main effect of Validity (F (3, 45) = 18.350, $p < .001$), where Bonferroni-corrected comparisons between the Validity conditions showed location-specific cueing effects with faster RTs following Same Location (490ms) than Same Side cues (510ms, $p = .029$). There was no significant difference in RTs between the Same Side and Neutral (531ms, $p = .105$) conditions, which shows that this effect was not driven by a general shift in attention to the correct side of space.

For the *inverted* pointing cues the analysis showed a significant main effect of Validity (F (3, 45) = 18.990, $p < .001$) and a significant interaction between Validity and SOA (F (3, 45) = 3.430, $p = .025$). Bonferroni-corrected comparisons between the Validity conditions at the short SOA showed no location-specific cueing effects (Same Location 489ms, Same Side 501ms, $p = .868$). The cue validity effect was limited to a general benefit to being cued to the correct side (Same Side 510ms, Neutral 528ms, $p = .002$) but not to a specific location on that side. Following the long SOA, Bonferroni-corrected comparisons did show location-specific cueing effects with faster RTs following Same Location (483ms) than Same Side cues (503ms, $p = .022$). There was no RT benefit to being cued to the Same Side over Neutral cues (517ms, $p = .373$), which shows that following the long SOA, the location-specific cueing effect was not driven by a general shift in attention to the correct side of space.

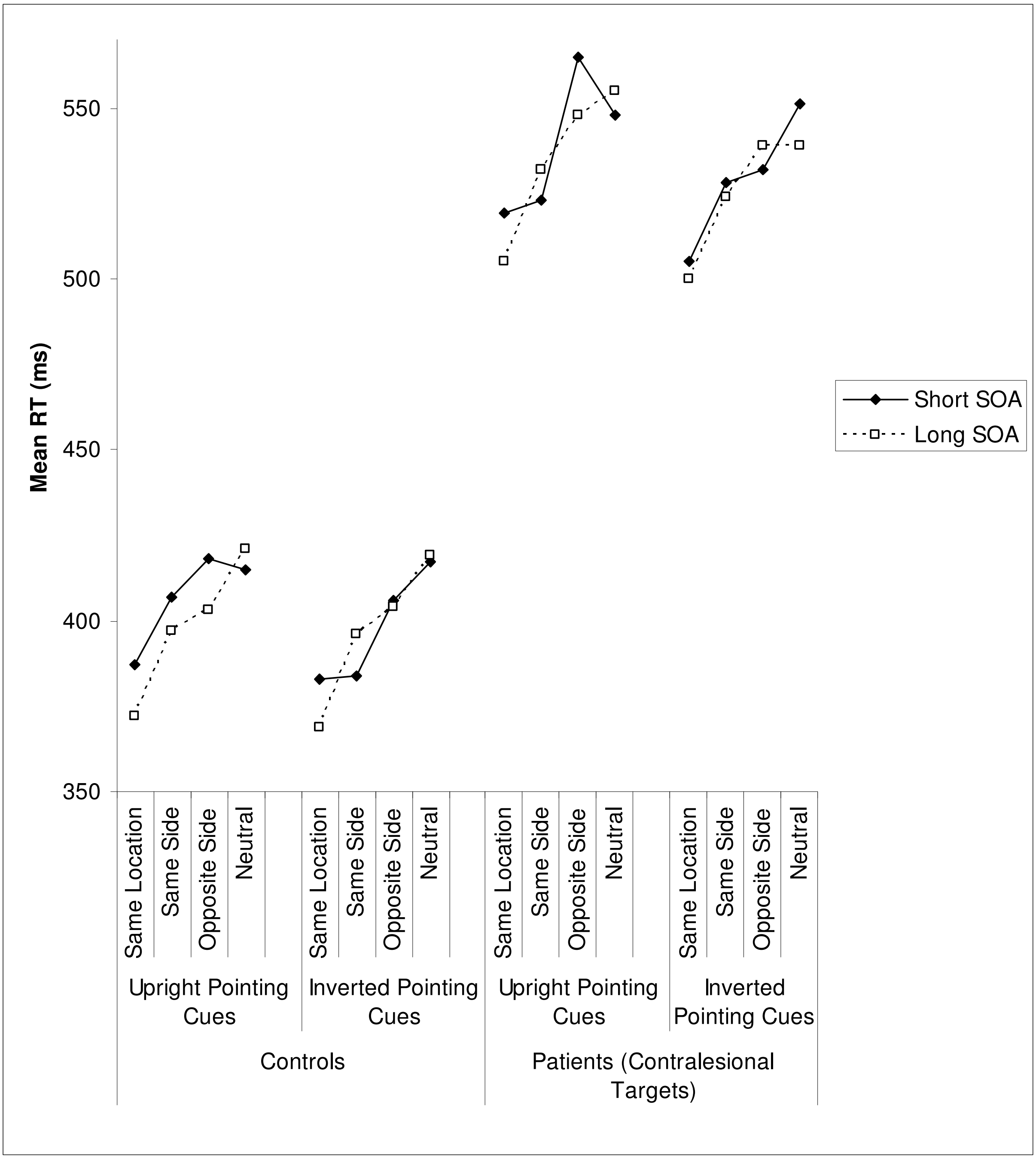

Figure 8. Illustration of Validity effects at both SOAs for the Control group and Patient group (for contralesional target detection) in the Upright and Inverted pointing cue experiments.

Table 2. A summary of all significant interactions involving the patient factor from the 4 (Patient: JB, MH, PF, RP) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: short, long) mixed design ANOVA for the upright and inverted schematic gaze cues.

Factors	Statistical Result
Validity * Patient	$F\ (9, 36) = 4.991, p < .001$
Side * Patient	$F\ (3, 12) = 186.343, p < .001$
SOA * Patient	$F\ (3, 12) = 24.651, p < .001$
Validity * Side * Patient	$F\ (9, 36) = 4.211, p = .001$
Validity * SOA * Patient	$F\ (9, 36) = 3.534, p = .003$
Validity * Side * SOA * Patient	$F\ (9, 36) = 2.608, p = .020$

2.7 Discussion

The analyses showed location-specific cueing effects for the upright and inverted pointing cues, across SOAs, for the controls and for patients' ipsilesional target detection. If the pointing cues were processed configurally in the same way as body recognition (Reed et al., 2003) then the cue validity effect would have been disrupted for the inverted pointing cue. This shows that at least in 'normal' perception (i.e. for controls and patients orienting to their unimpaired hemifield), pointing cues are not represented as part of the body as a configural whole (cf. Reed et al., 2003), but instead as separate symbolic directional cues. Nevertheless the cues are extremely reliable in terms of producing strong validity effects which occur reflexively, as reported for both eye gaze and arrow cues in the literature (Ristic et al., 2002).

For target detection on patients' contralesional side, there were location-specific cueing effects following both the short and the long SOA for upright pointing cues. This shows that patient group could use upright pointing gestures to cue their attention reflexively to specific locations in both hemifields, indicating that the canonical pointing gesture acts in much the same way as gaze cues (Vuilleumier, 2002) and in a more reliable way that symbolic arrows in Vuilleumier's (2002) patient group. However, when the pointing cues were inverted, the cueing effect was only location-specific following the long SOA but not following the short SOA. That is not to say that the inverted cues failed to produce *reflexive* cueing effects. At the short SOA there was still a significant advantage for being cued to the correct side relative to being invalidly cued to the opposite side, which is consistent with reflexive cueing in 'classic' paradigms where the target can appear at only one location on either side (e.g. Posner et al., 1984; Driver et al., 1999). It is surprising that the additional processing time required to orient attention to a specific location is only necessary for inverted and not upright pointing cues. Vecera and Rizzo (2004) have offered an account of reflexive eye gaze and arrow cueing in terms of rapid attentional orienting in response to over-learned associations between directionally meaningful stimuli. The results from human pointing cues in Experiment 2 can also be explained in these terms, that is, by reflexive orienting in response to learned associations between a pointing gesture and a given location in the environment. However, when the pointing cues are non-canonical this location-specific effect is slightly delayed in cases of disrupted spatial orienting (i.e. visual extinction), and early attention is distributed across one side of space (cf. Townsend & Courchesne, 1994). The fact that this effect only arises for inverted cues show that to some extent the body cue must be processed at the configural level, otherwise inversion would have no effect on attention (Reed et al., 2003). However, the disruption caused to configural processing of such a simplistic cue is likely to be very subtle, and only impedes performance when combined with other attentional deficits (in this case spatial reorienting).

Experiment 3: Symbolic Arrow Cue

2.8.1 Materials

The cue stimulus for this experiment was constructed following the details provided by Vuilleumier (2002). The arrow was composed of shapes (a circle, rectangle and arrowhead) which were drawn in Microsoft® Office PowerPoint® 2003. The rectangle shape and arrow head were fitted together and measured 2cm in length, and 0.8cm at the widest part of the arrowhead. The arrow was then positioned using Adobe® Photoshop® CS2 so that it appeared to point towards one of the four target locations. In the neutral condition, the arrow pointed straight downwards as in Vuilleumier's (2002) experiment. As in the previous Experiments, the target boxes measured 1cm² and were positioned 8.5cm from fixation, so that the overall image closely matched Vuilleumier's (2002) original arrow stimulus (see Figure 9).

Figure 9. An example of the symbolic arrow cue, in the same location validity condition.

2.9 Results

Within the patient dataset, misses and anticipatory responses (<100ms) were removed from further analyses (4.01% of total data set). Within each condition per patient, RTs outside of 2 standard deviations (SDs) of the mean were removed (5.12% of total data set) and a mean RT was calculated from the remaining data for each condition per session of each experiment. Within the control dataset, misses and anticipatory responses (<100ms) were removed from further analyses (0.04% of total data set). Within each condition for each patient, RTs outside of 2 standard deviations (SDs) of the mean were removed (4.98% of total data set) and a mean RT was calculated from the remaining data for each condition.

2.9.1 Controls vs. Patients – Ipsilesional Target Detection

The analysis revealed a significant main effect of Group (F (1, 9) = 6.594, $p = .030$) with controls (394ms) generally responding faster than patients (493ms). There was a significant main effect of Validity (F (3, 27) = 12.456, $p < .001$; see Figure 10) where Bonferroni-corrected comparisons show a general effect of the cue shifting attention to the correct side in general, but not to a specific location on that side. There was no significant difference in RTs between Same Location (424ms) and Same Side (440ms, $p = .080$) cues, but a significant advantage for Same Side cues over Neutral (455ms, $p = .033$). This effect is consistent across SOAs, which is indicative of reflexive orienting in response to the central arrow cue.

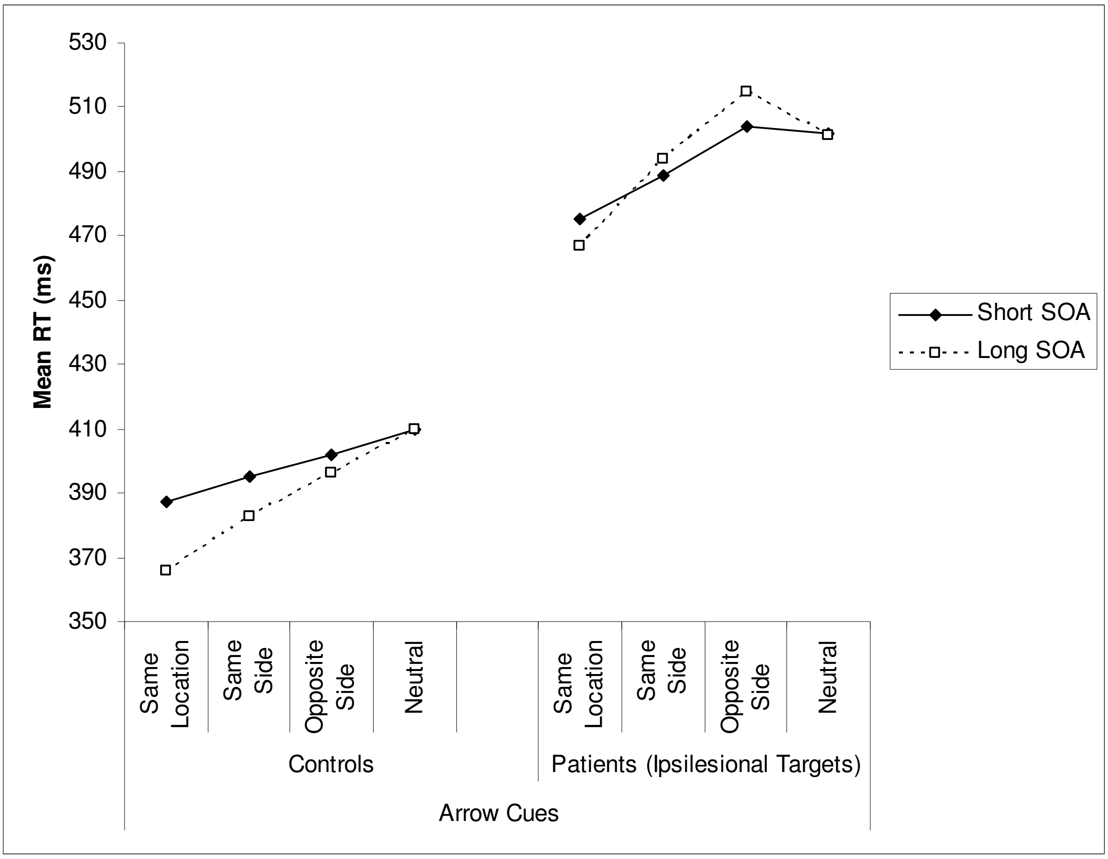

Figure 10. Illustration of Validity effects at both SOAs for the Control group and Patient group (for ipsilesional target detection) in the Arrow cue experiment.

2.9.2 Controls vs. Patients – Contralesional Target Detection

The analysis revealed a significant main effect of Group (*F* (1, 9) = 12.999, *p* = .006) with controls (394ms) generally responding faster than patients (541ms). There were significant main effects of Validity (*F* (3, 27) = 13.806, *p* < .001) and SOA (*F* (1, 9) = 9.521, *p* = .013; short 474ms, long 461ms). Bonferroni-corrected comparisons between the Validity conditions showed the same pattern of validity effects as for patient's ipsilesional target detection. That is, there was no RT advantage for Same Location (447ms) over Same Side (460ms, *p* = .151) cues, although there was a significant effect of attention being cued to the correct side in general, with faster RTs for Same Side (460ms) than Neutral cues (485ms, *p* = .041; see Figure 11).

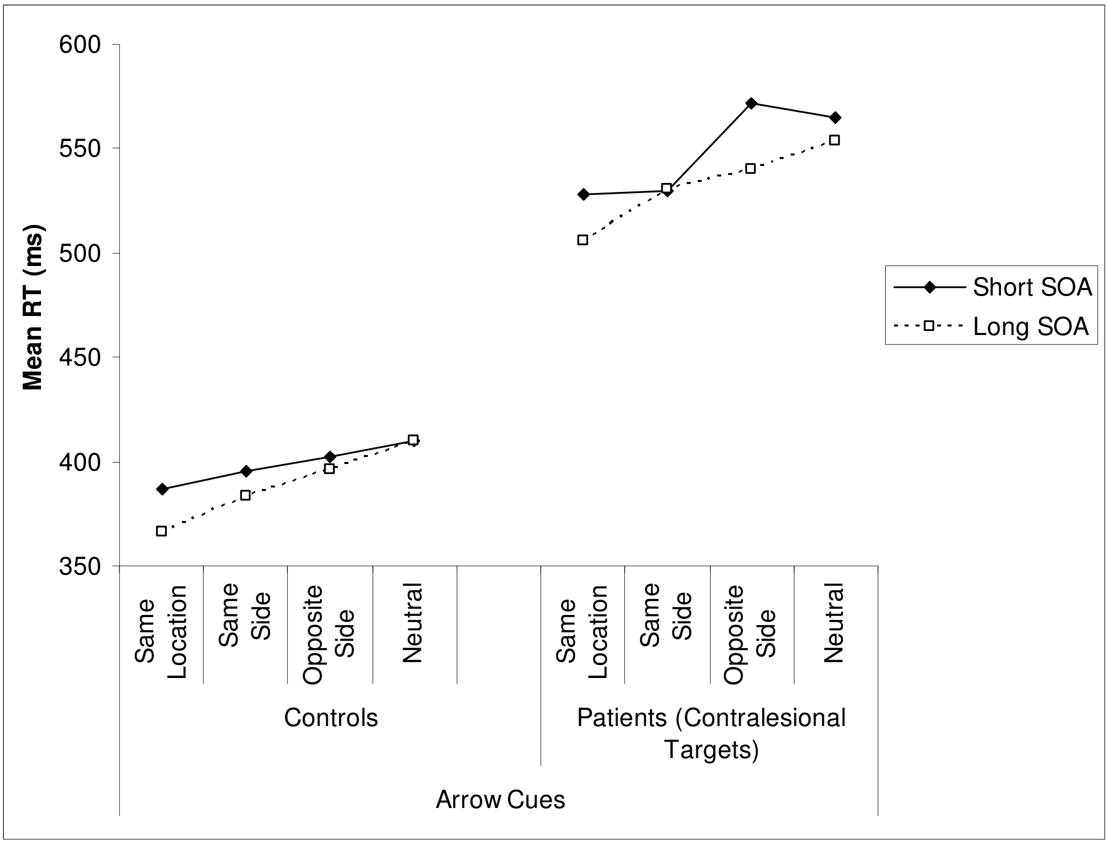

Figure 11. Illustration of Validity effects at both SOAs for the Control group and Patient group (for contralesional target detection) in the Arrow cue experiment.

2.9.3 Parietal-Damaged Patients

There were significant main effects of Patient (*F* (3, 12) = 21.083, *p* < .001), Validity (*F* (1.7, 19.9) = 12.354, *p* = .001), and Side (*F* (1, 12) = 60.334, *p* < .001; ipsilesional 493ms, contralesional 540ms). There were significant interactions between Side and Patient (*F* (3, 12) = 31.660, *p* < .001) and between Validity, Side and Patient (*F* (9, 36) = 3.054, *p* = .008). Since we were interested in exploring the performance of the patient group as a whole, rather than on a case-by-case basis, this three-way interaction was collapsed across the patient factor to investigate the Validity by Side interaction further. The 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within-subjects ANOVA showed significant main effects of Validity (F (3, 45) = 10.113, $p < .001$) and Side (F (1, 15) = 8.460, $p = .011$) but no interaction ($p = .601$). This shows that the previous three way interaction was driven by differences between the patients in the magnitude of their individual effects of Side, which will not be explored further here. Bonferroni-corrected comparisons between the Validity conditions showed no evidence of location-specific cueing since there was no significant difference in RTs between Same Location (494ms) and Same Side (511ms, $p = .460$) conditions. However, Same Location cues elicited significantly faster RTs than Opposite Side (533ms, $p = .008$) and Neutral (530ms, $p = .001$) cues, and Same Side (511ms) cues elicited significantly faster RTs than Opposite Side (533ms, $p = .009$). This shows that the arrow cue did have some directional cueing effect, but this was limited to a shift in attention to the correct side of space, regardless of whether the target appeared on the patients' ipsilesional or contralesional side.

2.10 Discussion

The results of Experiment 3 showed that the cueing effect of the symbolic arrow was consistent across the controls and patient groups, and across SOAs. The cue-validity effect was one of a general shift of attention to the correct hemifield, rather than a location-specific cueing effect found with gaze (for ipsilesional targets in patients; Experiment 1) and upright pointing cues (Experiment 2). Nevertheless, this effect was present at both the short and long SOAs, indicating reflexive attentional reorienting in both normal observers and parietal-damaged patients. Vuilleumier (2002) found a minimal effect of the arrow cue, in the form of a cost to RTs in disengaging attention contralesionally after being cued to the ipsilesional side following a long SOA. However in our Experiment here, patients could use the arrow cue to guide their attention reflexively to the correct side, for both contralesional and ipsilesional targets. Therefore, the results of this experiment support the findings of Ristic et al. (2002) and Tipples (2002) who showed that symbolic arrows can induce reflexive shifts of attention in normal observers. Cross-experiment analyses were carried out to directly compare the effects of the arrow cue with the pointing gesture, to distinguish between social and symbolic mechanisms in the attention shifting of the patients and normal controls.

2.11 Cross-Experiment Analyses

To investigate differences in the magnitude of validity effects between the cues, separate analyses were carried out between the types of cues. To find out whether a pointing gesture elicits the same validity effects as a gaze shift, data from the upright pointing cue experiment were analysed alongside data from the upright gaze cue experiment. To explore the potential differences in the validity effects associated with pointing gestures and arrow cues, these were also compared directly in a further analysis. These were the main comparisons pertinent to our research questions, and since the individual cue analyses already contain many experimental factors, it was decided that entering the three cue types into the same analysis would be confusing. A discussion of results of these cross-experiment analyses will be included in the Main Discussion at the end of this Chapter.

Gaze vs. Pointing Cues

The following analysis was carried out to compare the relative validity effects of the pointing gesture and the schematic gaze cue, between the age-matched controls and the parietal-damaged patients. Data were entered into a 2 (Group: Controls, Patients) * 2 (Cue type: Gaze, Pointing) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA, separately for patients ipsilesional and contralesional target trials.

Controls vs. Patients – Ipsilesional Targets

The analysis revealed significant main effects of Group (F (1, 9) = 9.978, p = .012; Controls 395ms, Patients 494ms) and Validity (F (3, 27) = 26.200, p < .001). Bonferroni-corrected comparisons between the Validity conditions showed location-specific cueing effects with faster RTs following Same Location (422ms) than Same Side cues (443ms, p < .001). There was no RT benefit to being cued to the Same Side over Neutral cues (454ms, p = .324), which shows that the location-specific cueing effect was not driven by a general shift in attention to the correct side of space (see Figure 12).

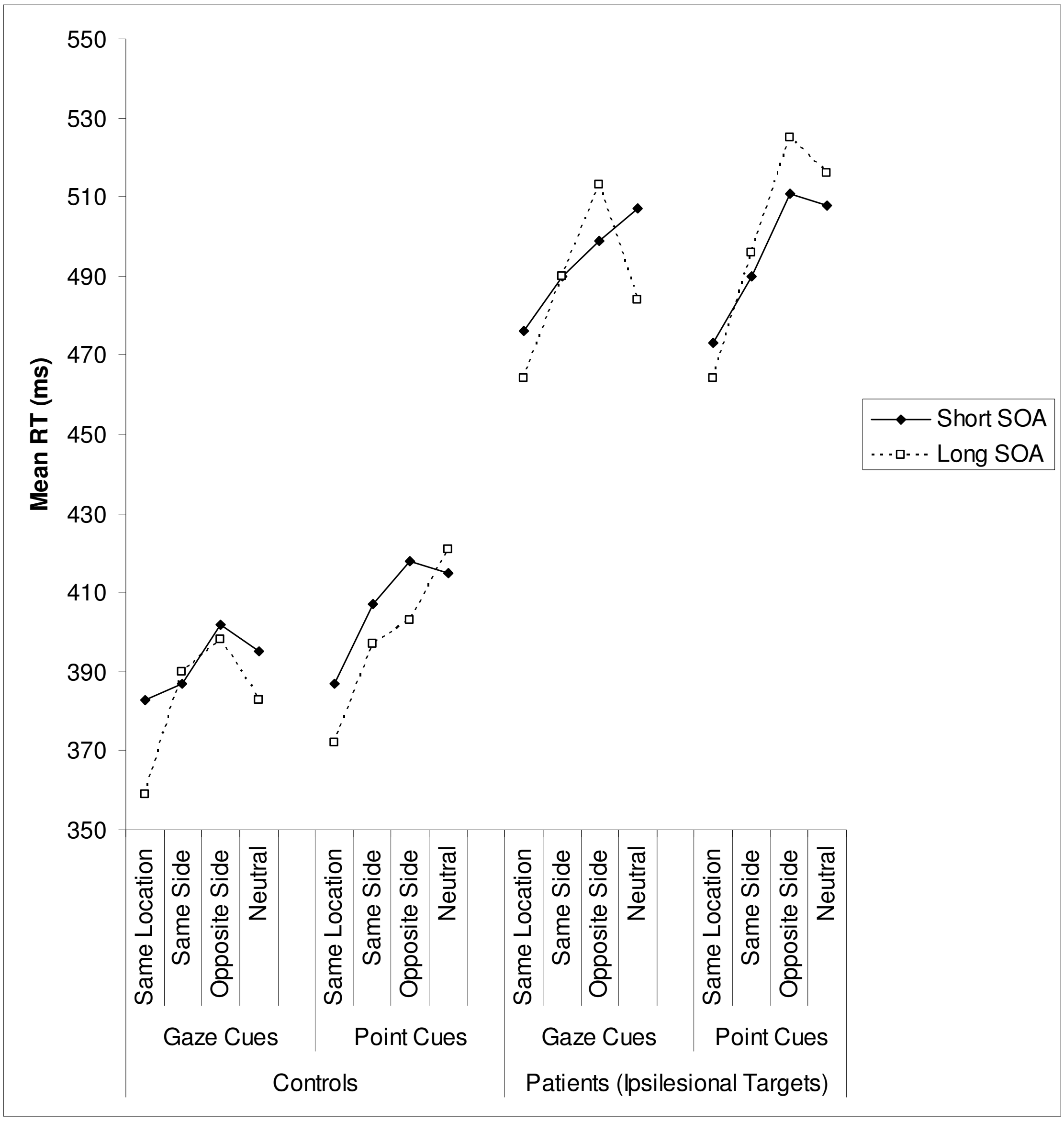

Figure 12. Illustration of Validity effects across SOAs for the Control group and Patient group (ipsilesional target detection) between the Gaze and Pointing cue experiments.

Controls vs. Patients – Contralesional Targets

The analysis revealed significant main effects of Group (*F* (1, 9) = 16.959, *p* = .003; Controls 395ms, Patients 532ms) and Validity (*F* (3, 27) = 13.730, *p* < .001), and a significant interaction between Cue Type, Validity and Group (*F* (3, 27) = 3.287, *p* = .036). This three-way interaction was decomposed by separate 2 (Cue type: Pointing, Gaze) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) within-subjects ANOVAs for each group (controls, patients). For the control group the analysis showed a significant main effect of Validity (*F* (3, 18) = 26.156, *p* < .001), where Bonferroni-corrected comparisons showed location-specific cueing effects with faster RTs following Same Location (375ms) than Same Side cues (395ms, *p* < .001). There was no RT benefit to being cued to the Same Side over Neutral cues (404ms, *p* > .999), which shows that the cueing effect was not driven by a general shift in attention to the correct side of space. For the patient group the analysis showed no significant main effects or interactions (all *p*s > .104).

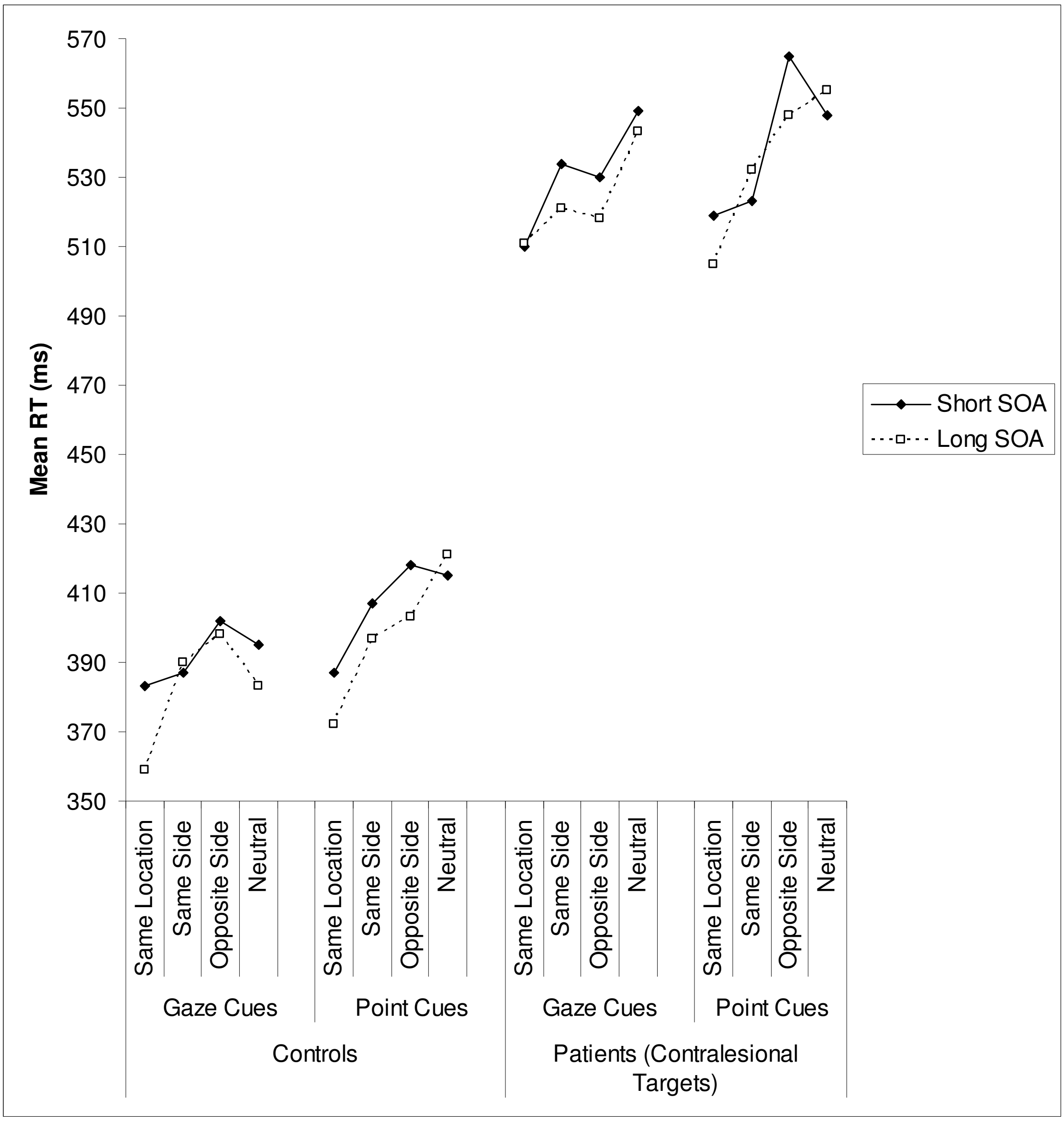

Figure 13. Illustration of Validity effects across SOAs for the Control group and Patient group (contralesional target detection) between the Gaze and Pointing cue experiments.

Pointing vs. Arrow Cues

The following analysis was carried out to compare the relative validity effects of the pointing gesture and the schematic gaze cue, between the age-matched controls and the parietal-damaged patients. Data were entered into a 2 (Group: Controls, Patients) * 2 (Cue type: Pointing, Arrow) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA, separately for patients ipsilesional and contralesional target trials.

Controls vs. Patients – Ipsilesional Targets

The analysis revealed significant main effects of Group (F (1, 9) = 7.751, p = .021; Controls 398ms, Patients 496ms) and Validity (F (2, 17.7) = 22.475, p < .001). Bonferroni-corrected comparisons showed location-specific cueing effects with faster RTs following Same Location (424ms) than Same Side cues (444ms, p = .001). In addition there was a RT benefit to being cued to the Same Side over Neutral cues (460ms, p = .024), which suggests that the location-specific cueing effect may be driven by a general benefit of being cued to the correct side (see Figure 14).

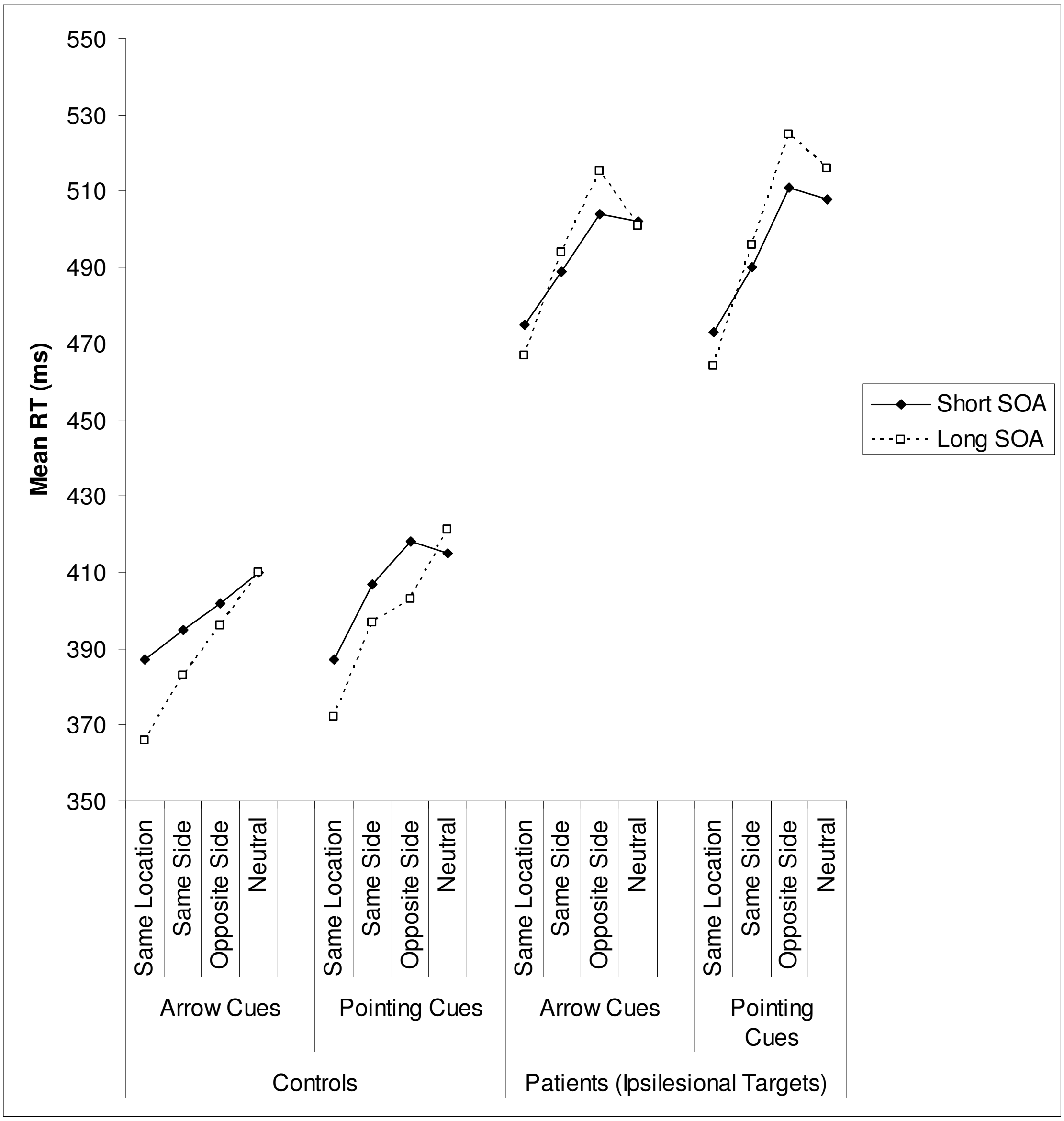

Figure 14. Illustration of Validity effects across SOAs for the Control group and Patient group (ipsilesional target detection) between the Arrow and Pointing cue experiments.

Controls vs. Patients – Contralesional Targets

The analysis revealed significant main effects of Group (*F* (1, 9) = 15.031, *p* = .004; Controls 398ms, Patients 539ms), Validity (*F* (1.4, 12.7) = 15.041, *p* < .001), SOA (*F* (1, 9) = 7.954, *p* = .020; short 473ms, long 464ms) and a significant Validity by SOA interaction (*F* (3, 27) = 5.125, *p* = .006; see Figure 15). Bonferroni-corrected comparisons between the Validity conditions at the *short* SOA showed no evidence of location-specific cueing since there was no significant difference in RTs between Same Location (455ms) and Same Side (464ms, *p* = .851) conditions. However, Same Location and Same Side cues elicited significantly faster RTs than Opposite Side (489ms, *p* = .002) cues. This shows that the overall there was some directional cueing effect, but this was limited to a shift in attention to the correct side of space. Following the long SOA, Bonferroni-corrected comparisons showed location-specific cueing effects with faster RTs following Same Location (437ms) than Same Side cues (461ms, *p* = .015). In addition there was no RT benefit to being cued to the Same Side over Neutral cues (485ms, *p* = .075), which shows that the effect was purely location-specific and not a general benefit of being cued to the correct side.

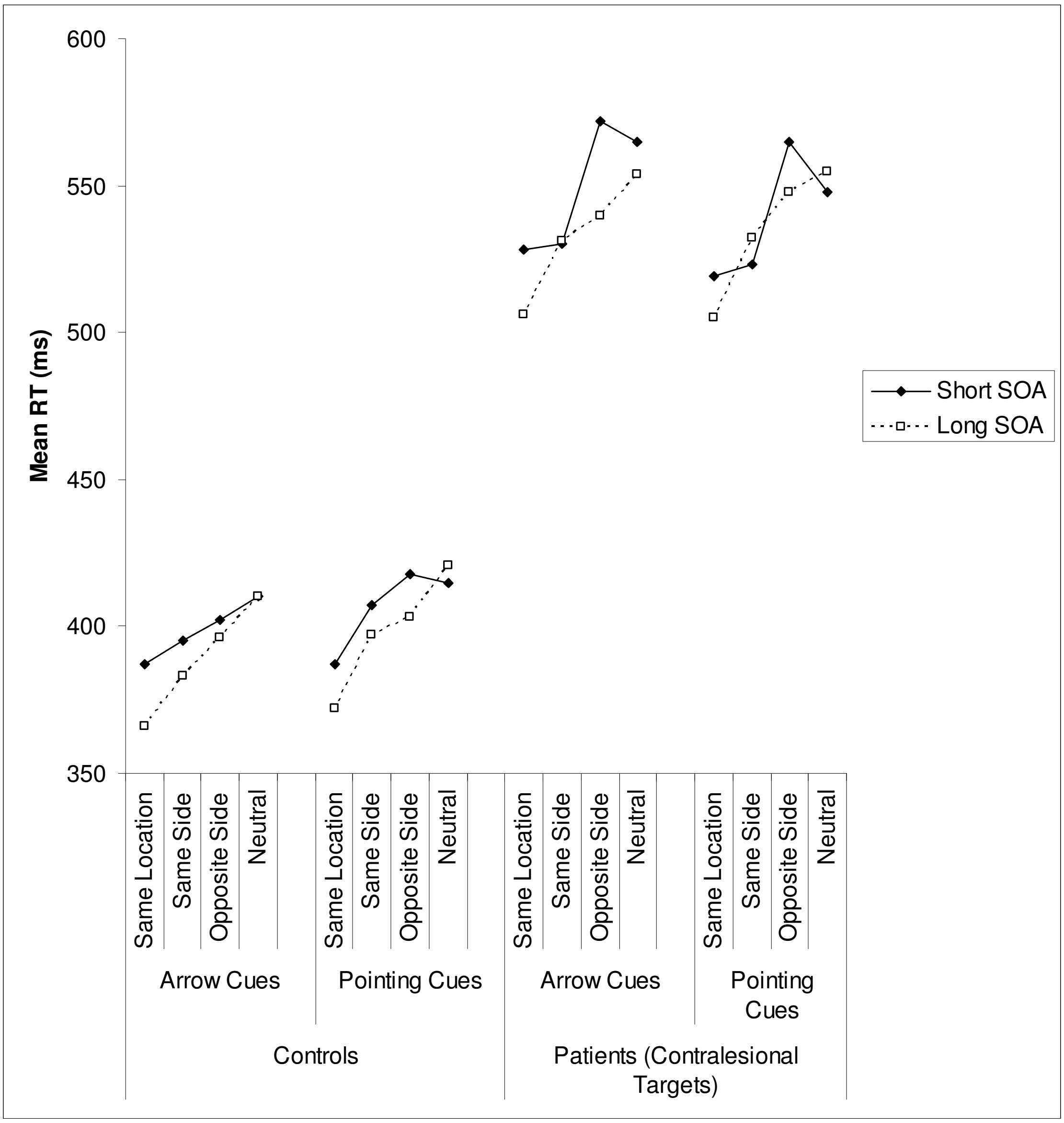

Figure 15. Illustration of Validity effects across SOAs for the Control group and Patient group (contralesional target detection) between the Arrow and Pointing cue experiments.

2.12 Main Discussion

Experiments 1 and 3 were designed to validate the findings of Vuilleumier (2002) in a larger dataset parietal damaged group, and in a more suitably age-matched control group. Furthermore, the same paradigm was employed to address the relatively novel research question of whether pointing gestures can elicit location-specific cueing effects. The analyses of the validity effects for each cues shows that controls seem to orient to targets in a similar way to patients when the targets appear on the ipsilesional side. However, when the targets appear on the patients' contralesional side not only are RTs slower, as would be expected as a result of their visual extinction, but validity effects are different with respect to controls.

Indeed the results from controls in Experiment 1 mirrored Vuilleumier's (2002) reflexive and location-specific cueing effects of eye gaze, and this pattern of attentional reorienting was also found in the parietal-damaged patient group for ipsilesional target detection. However, contrary to Vuilleumier (2002) the eye gaze cue was not successful in directing patients' attention to specific locations on their contralesional side, rather this effect was of a general cueing to this side. The differences in results could be due to Vuilleumier's (2002) patients displaying visual spatial neglect and our patients displaying visual extinction. Karnath et al. (2001; see *The Neuro-Anatomy of Neglect and Extinction* in Appendix I) link neglect with lesions to the Superior Temporal Gyrus (STG) which is responsible for spontaneous exploration of the environment in unimpaired observers. However, Karnath et al. (2003) later showed that visual extinction is associated with lesions to the TPJ which is implicated in detecting salient stimuli and changes in the environment – and this area is also implicated in gaze following and ToM (Saxe & Kanwisher, 2003; Gallagher et al., 2000). Therefore, Vuilleumier's patients could use eye gaze cues (via the TPJ) to direct attention to specific areas of contralesional space, because the 'social salience' of gaze could effectively shift their attention to the neglected side. However, since gaze meaning is also processed via the TPJ, the extinction patients in our study were not able to make use of these cues to shift attention to specific locations on the extinguished side.[4] Since the patients could utilise the gaze cues to elicit location-specific reorienting to the ipsilesional side, the results do not reflect an inability to process the meaning or directionality of gaze, but are more indicative of a less focussed shift of attention to the contralesional side than to the ipsilesional side (cf. Townsend & Courchesne, 1994).

Experiment 3 showed that patients could use the arrow cue to guide their attention reflexively to the correct side, for both contralesional and ipsilesional targets, and this effect was mirrored in control subjects. These results show a stronger cueing effect of arrows than shown by Vuilleumier (2002), which may reflect the larger amount of data collected in our experiment which allowed for better detection of more generalised effects of cue validity. However, the main purpose of the experiments in Chapter 1 was to validate Vuilleumier's (2002) location-specific cueing paradigm and assess the cueing effects of novel pointing gestures in relation to the established effects of gaze shifts and arrows in parietal-damaged patients. Indeed the patients showed very similar effects of pointing and gaze cues, although in the cross-experiment analyses showed that patients appeared to show no cueing effects for either gaze or pointing for contralesional targets. This is due to the validity effects generally being smaller across the cue types in the patient group as compared to the control group, which may be a matter of power since the patient group is relatively small. Indeed when analysed separately in earlier analyses the patient group showed location-specific cueing for both gaze and pointing cues for ipsilesional

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[4] Note that these are simply suggestions as to why different effects occur between the patients in Vuilleumier's (2002) study and those reported here. It is beyond the scope of this research to implicate specific brain regions in the attentional and social orienting mechanisms of these patients, but basic lesion details are presented in Appendix II.

targets, and similar general cueing to the correct side in response to both cues for contralesional targets. To our knowledge, this is the first line of evidence that gaze *and* pointing cues can induce reflexive 'social' orienting in parietal damaged patients. Furthermore the cueing effects of gaze and pointing are location-specific for ipsilesional target detection and in patients and both sides in control subjects, whereas effects for arrow cues are general to side and not location on both sides in both patients and control groups. We propose that this supports the existence of a specialised system for processing socially relevant stimuli (Haxby et al. 2000), which is not restricted to the processing of facial information, but also extends to gestures and cues from the human body.

Nevertheless, it is possible that the location-specific cueing effect found with pointing cues but not with arrows is due to the implied motion of the pointing cue, or proximity between cue and target. The outstretched arm of the central figure in Experiment 2 necessarily extends further towards the target locations than the arrow (which was designed by Vuilleumier to be matched in size to the eye region of the face), and as such has a much greater implied motion than the arrow and gaze cues. Therefore it is possible it is the visual salience rather than the social salience of this cue that allows for location-specific cueing effects in controls and ipsilesional target detection for patients. This will be investigated in Chapter 3, where the use of realistic social cues allowed for the manipulation of a much more subtle pointing gesture, and for this investigation of gaze inversion effects in much more visually complex stimuli. Therefore this will allow us to answer the question of whether the null effect of inversion on gaze cueing in Experiment 1 was due to the simplistic nature of the stimuli being relatively insensitive to inversion, or whether parietal damaged patients and older controls simply do not show sensitivity to gaze inversion when processing eye gaze direction. These alternatives will be addressed and discussed in the following Chapter.

CHAPTER 3:

THE EFFECT OF REALISTIC SOCIAL CUES ON THE REORIENTING OF VISUAL ATTENTION IN PARIETAL-DAMAGED PATIENTS AND AGE-MATCHED CONTROLS

3.1 Introduction

It has been proposed that much of what cognitive psychologists and neuroscientists know about attention is built upon findings from highly controlled experimental paradigms (Smilek et al., 2006). Kingstone et al. (2004) have argued that although we have learned a great deal, our learning is indeed limited as a result of employing these rigid and artificial procedures. Smilek et al. (2006) suggest that simply using more meaningful stimuli in laboratory experiments may allow a different story to be told about the nature of attention, as the real world consists of a much richer and more complex set of stimuli and occurrences than are typically presented in experimental procedures. They urge researchers to explore human attention to real world scenes in an approach they have called 'Cognitive Ethology'. The cognitive neuroscience approach to attention attempts to uncover underlying mechanisms in attention by controlling stimuli and behaviour as far as possible, with one of the most popular methods being the Posner cueing paradigm (Posner, 1980). Since the aim of this thesis is to investigate social orienting in different populations, the socially meaningful stimuli presented in the following experiments are consistent with the Cognitive Ethology approach. However, the Posner cueing paradigm typically consists of a single central cue and peripheral target locations. In order to keep the experiments in line with those of Vuilleumier (2002) which have formed the basis for the research questions here, more socially meaningful stimuli will be used as the central stimulus. Not only will this give a more ecologically valid approach to studying attention, but will also retain the scope to compare findings against those from previous experiments using very simple, schematic gaze and pointing stimuli (see Chapter 2).

The following series of experiments replicate the methods and procedures of Chapter 2 with stimuli designed to maximise social relevance of the cues. Photograph stimuli were presented, where a human face with averted gaze, a human body making a subtle pointing gesture and a human hand with pointing finger could each cue a certain target location. The latter experiment was included to investigate whether the pointing gesture would be equivalent to a symbolic arrow when the rest of the human figure is absent. The subtle pointing gesture was developed to establish whether the validity effects of the pointing cue in Chapter 2 were the result of a) apparent biological motion, and b) proximity of cue to target. That is, although the cue did not actually move, the rapid change from neutral stance to pointing gesture may give the illusion of movement, where the final position of the pointing hand is closer to the cued target location than are the eyes or the arrow in the other experiments. Therefore, the pointing 'across the body' cue reduces both the extent of the apparent motion, and the proximity between cue and target, equating the cue as far as possible to the gaze stimuli. As in Chapter 2, the stimuli in the following experiments were presented in their upright and inverted orientations in order to investigate whether there was an advantage (in terms of validity effects) when socially relevant cues are perceived in their canonical orientation. That is, are humans programmed to rapidly orient attention to another's gestures only when that person is perceived in their normal, upright position, or does the brain make sense of this information in other visual orientations? Research has shown different effects of gaze inversion on covert attention in different populations

(Langton & Bruce, 1999; Kingstone et al., 2000; Swettenham et al., 2003), but this has not yet been investigated in parietal-damaged patients. Specifically, the following research questions are posed in this Chapter:

1) The results from experiments in Chapter 2 suggest no effects of inversion for schematic gaze stimuli. However, this may be due to the simplicity of the cues in Experiment 1, since previous research showing inversion effects has typically used photographic or digitised facial images. It is hypothesised that realistic faces will be sensitive to inversion effects and hence the parietal-damaged patients and controls will show a reduced cueing effect for inverted than for upright realistic gaze cues, as found in normal observers (Langton & Bruce, 1999).

2) We also want to compare the validity effects of gaze shifts and the more subtle pointing cues. If the similarity in cueing effect for gaze and pointing cues in Chapter 2 was due to the social salience of gaze being matched by the visual salience of pointing, then for a relatively less visually salient pointing gesture we should see a reduced cue-validity effect, relative to gaze cueing. However, if the similarity of cueing effects was indeed due to the social salience of both the gaze and pointing cues in Chapter 2, then this similarity should still be present in this Chapter when a more subtle pointing gesture is presented. This will be assessed in cross-experiment analyses.

3) How does the hand cue compare to the full-body pointing cue? That is, is it necessary that the hand is perceived in the context of the human body for the validity effects to be as strong? It was hypothesised that if a pointing hand is still perceived as a socially relevant stimulus when it is not presented in the context of a human body, then this experiment should yield similar validity effects as the whole-body pointing cues. However, if the validity effect is of lesser magnitude, then it can be concluded that a pointing hand is processed in a similar way as

symbolic arrows, and hence pointing gestures need to be perceived in the context of a human body in order to be processed by ‘social networks’ in the brain.

3.2 Methods

3.2.1 Participants

Six patients DB, DT, JB, MH, PF and RP (2 female; mean age 65.7 years; range 56 – 75 years; SD 8.6) completed 4 runs of each of the experiments detailed below. Each patient took between 20 and 30 minutes to complete each experiment. The experiments were presented in a random order across multiple sessions, according to patient availability. All patients presented with visual extinction on double simultaneous stimulation after sustaining damage to one or both parietal lobes. DB, DT and MH all showed visual extinction of the right-sided item, whereas patients JB, RP and PF extinguished the left-sided item. (Note that patients MH and PF have bilateral parietal damage). Please see Appendix II for further details of patient lesions and demographics.

Ten age-matched control participants (mean age 68.6 years; range 57 – 77 years; SD 7.2) completed all of the experiments detailed below in a random order across two testing sessions, taking between 15 and 20 minutes to complete each experiment. In contrast to the patient group, the controls were only tested on one run of each experiment. These participants had no history of neurological damage and were paid a small fee for their time. Note that the same patients and controls took part in all experiments in this Chapter.

3.2.2 Design

The design for all experiments in this Chapter was the same as that of Experiment 1. See section *2.2.2 Design* in Chapter 2 for details.

3.2.3 Procedure

The procedure for all experiments in this Chapter was exactly the same for Experiment 1. See Chapter 2 section *2.2.3 Procedure* for details.

Experiment 4: Upright vs. Inverted Realistic Eye Gaze Cues

3.2.4 Materials

The central stimulus was equated for size to the schematic face in Experiment 1 as closely as possible (see Chapter 2 section *2.2.4 Materials*). A model posed with a neutral facial expression while photographs were taken of the face with the eyes looking straight ahead at the camera (neutral gaze) and looking towards the upper left, upper right, lower left, and lower right (all examples of averted gaze). Adobe® Photoshop® CS2 was used to manipulate the images, where the eyes from each photograph were masked over the same basic face image, so that the only change in the stimulus between conditions was in the direction of gaze, rather than subtle changes in the overall image (e.g. lighting, expression, shifts of position, etc). All face images were trimmed of external features (ears, hair, neck, etc) and were resized to fit a virtual 6cm*4cm rectangle. Since human faces are not round, this was the best possible match to the schematic face presented in Experiment 1, without making the human face look too caricatured (see

Figure 16). The face images appeared centrally, and the target dimensions and positions were the same as those described in Experiment 1 (see Chapter 2 section *2.2.4 Materials*). For the Inverted Realistic Gaze cue, the materials were the same as described except that the central face cue was rotated through 180° so that it appeared upside-down.

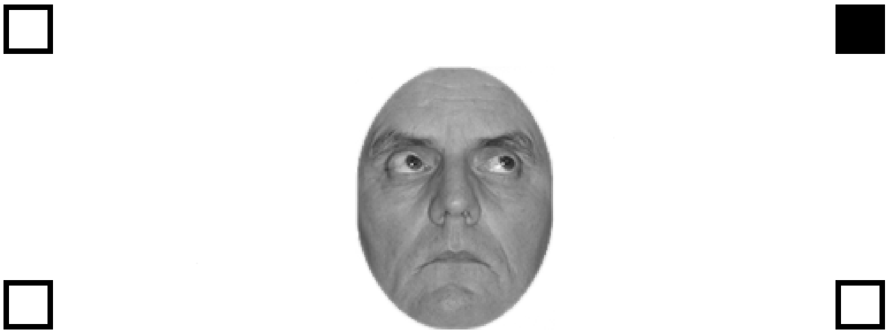

Figure 16. An example of a valid Same Location upright realistic eye-gaze cue.

3.3 Results

The results were analysed in the same way as for the experiments in Chapter 2. For the controls in Experiment 4, misses and anticipatory responses (<100ms) were removed from further analyses (0.23% of total dataset). Within each condition per session, RTs outside of 2 SDs of the mean were removed (4.89% of total dataset) and a mean RT was calculated from the remaining data for each experiment. For the patients, misses and anticipatory responses (<100ms) were removed from further analyses (3.54% of total dataset). Within each condition, RTs outside of 2

SDs of the mean were removed (7.27% of total dataset) and a mean RT was calculated from the remaining data for each condition in each experiment.

3.3.1 Controls vs. Patients – Ipsilesional Target Detection

The analysis showed no significant main effects of Group (F (1, 14) = 1.483, p = .243) or Orientation (F (1, 14) = 0.028, p = .869). There were significant main effects of Validity (F (3, 42) = 7.605, p < .001) and SOA (F (1, 14) = 14.408, p = .002) which were qualified by a Validity * SOA interaction (F (3, 42) = 3.608, p = .021), and an additional interaction between Orientation * Validity (F (3, 42) = 3.756, p = .018; see Figure 17).

For the Orientation * Validity interaction, Bonferroni-corrected comparisons between Validity conditions for the *Upright* gaze cues showed the Same Location cues (466ms) elicited faster RTs than Same Side cue (476ms) although this difference did not quite reach statistical significance (p = .078). There was no significant difference between RTs following Same Side (476ms) and Opposite Side (489ms; p = .107) cues which shows that the invalid cueing effect was the same within and between hemifields. In addition, there was no significant difference in RTs between the Same Side and Neutral cues (480ms; p > .999) which supports that orienting was not generally to one side, but rather it was location-specific. However, Bonferroni-corrected comparisons between Validity conditions for the *Inverted* gaze cues showed no significant differences in RTs between any of the Validity conditions (Same Location 472ms; Same Side 481ms; Opposite Side 481ms; Neutral 486ms; all ps > .129).

For the Validity * SOA interaction, Bonferroni-corrected comparisons between Validity conditions following the *short* SOA showed no significant differences in RTs between any of the Validity conditions (Same Location 481ms; Same Side 485ms; Opposite Side 489ms; Neutral

488ms; all *p*s > .263). However, following the *long* SOA, there was evidence of location-specific cueing, with faster RTs following Same Location (458ms) than Same Side cues (472ms, *p* = .007), and no advantage for Same Side cues over Opposite Side (489ms, *p* .131) or Neutral cues (478ms, *p* > .999). This shows that following the long SOA, gaze cueing was location-specific and not general to side, and that attentional shifts were the same within and between hemifields.

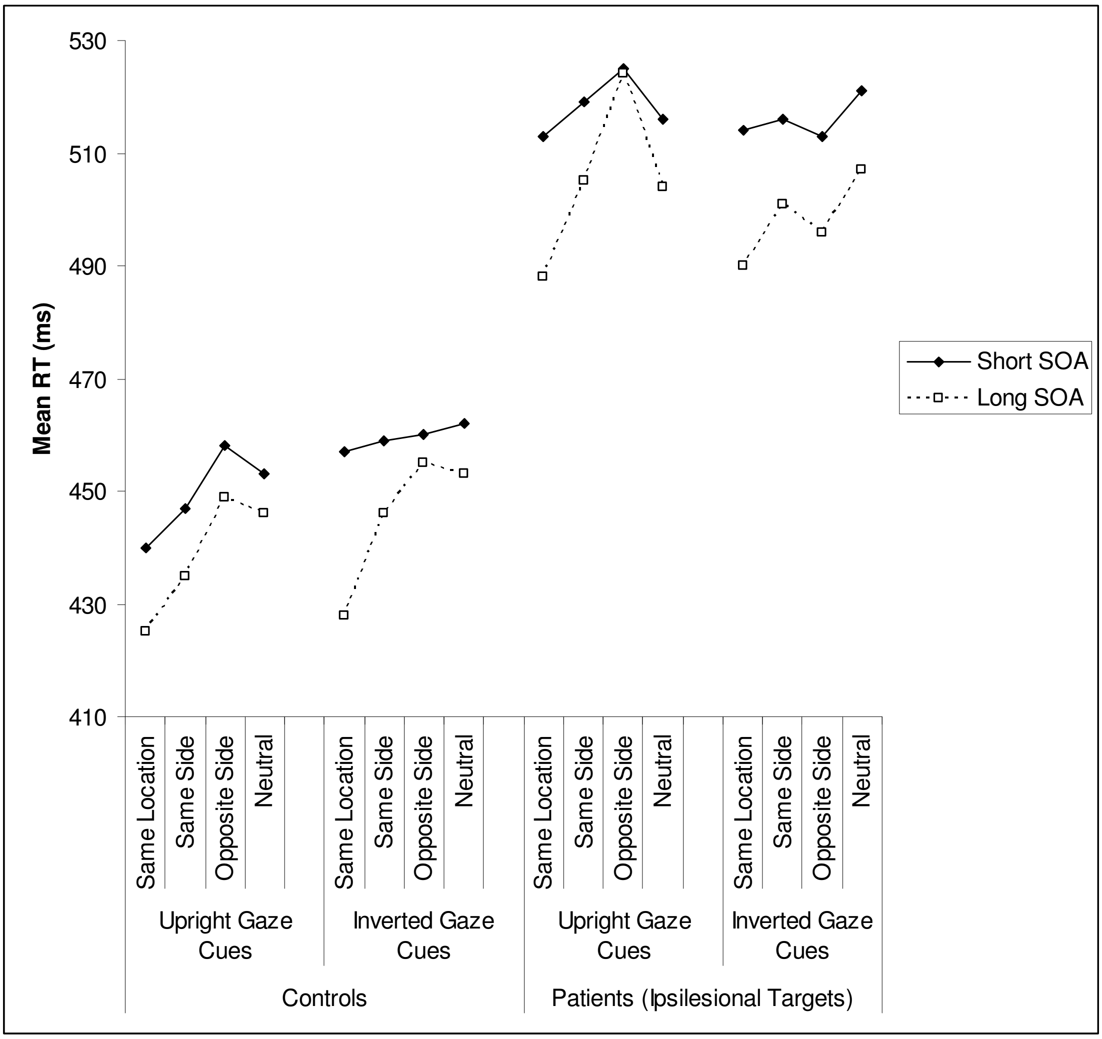

Figure 17. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (ipsilesional targets) in the Upright and Inverted Gaze cue experiments.

3.3.2 Controls vs. Patients – Contralesional Target Detection

There was a significant main effect of Group (*F* (1, 14) = 5.938, $p = .029$), where patient RTs (562ms) were generally slower than control RTs (448ms) as would be expected for contralesional target detection. There were also significant main effects of Validity (*F* (3, 42) = 8.602, $p < .001$) and SOA (*F* (1, 14) = 8.848, $p = .010$; short SOA 511ms, long SOA 499ms; see Figure 18). Bonferroni-corrected comparisons between the Validity conditions showed evidence of location-specific cueing, where RTs were faster following Same Location cues (495ms) than Same Side cues (504ms, $p = .028$), Opposite Side (510ms, $p = .011$) and Neutral cues (511ms, $p = .025$) but there was no significant difference in RTs between the latter three conditions (all *p*s > .365).

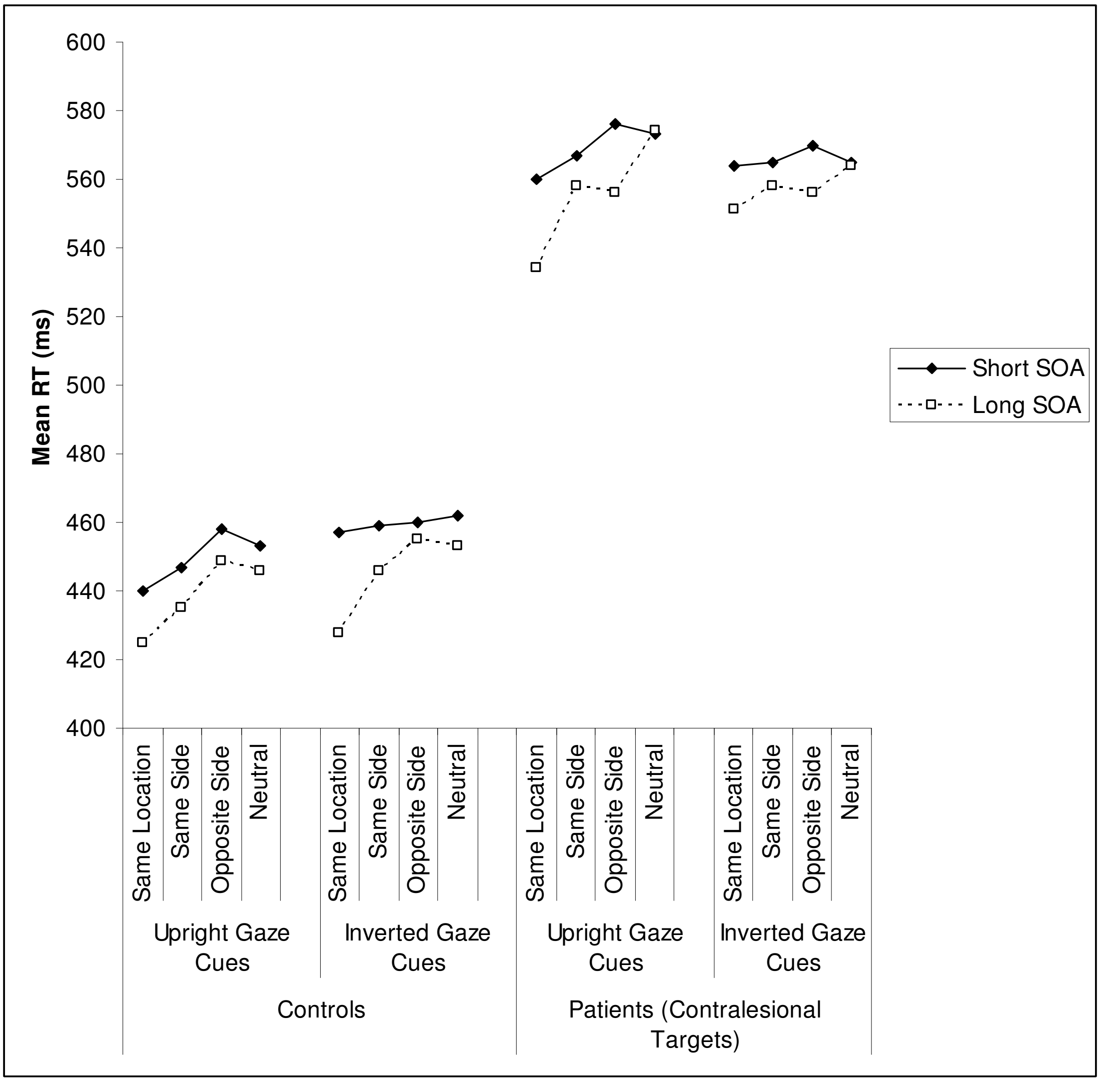

Figure 18. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (contralesional targets) in the Upright and Inverted Gaze cue experiments.

3.3.3 Parietal-Damaged Patients

The analysis revealed no significant main effect of Orientation (*F* (1, 18) = .049, *p* = .827), although there was a significant interaction between Orientation * Patient *F* (5, 18) = 3.327, *p* = .027 where three patients (JB, PF, MH) showed an RT advantage for upright over inverted gaze cues, and the remaining three patients (DB, DT, RP) showed the opposite pattern of faster RTs for inverted cues than for upright cues. However, paired samples t-tests revealed that only patient JB showed a statistically significant difference in RTs between upright and inverted gaze cues, with the difference displayed by patient PF approaching significance (see Table 3).

Table 3. Mean differences in RTs between the upright and inverted gaze cue experiments per patient, with results of paired t-tests.

Patient	Upright Gaze Cues (mean RT)	Inverted Gaze Cues (mean RT)	Mean RT Difference	Statistical Result
DB	628 ms	572 ms	56 ms	t (3) = 2.145, p = .121
DT	589 ms	543 ms	46 ms	t (3) = 1.086, p = .357
JB	577 ms	641 ms	-64 ms	t (3) = -6.242, p = .008*
MH	403 ms	420 ms	-17 ms	t (3) = - .443, p = .688
PF	569 ms	617 ms	-49 ms	t (3) = -2.649, p = .077*
RP	455 ms	412 ms	43 ms	t (3) = 1.755, p = .178

There was a significant main effect of Validity (*F* (3, 54) = 10.028, *p* < .001), which interacted with the Patient factor (*F* (15, 54) = 3.707, *p* < .001), and a significant main effect of Side (*F* (1, 18) = 236.150, *p* < .001), which interacted with the Patient factor (*F* (5, 18) = 23.495, *p* < .001). A significant main effect of SOA (*F* (1, 18) = 21.016, *p* < .001) also interacted with the Side and Patient factors: Side * SOA * Patient (*F* (5, 18) = 3.899, *p* = .014).

The analysis also revealed some higher-level interactions which approached significance. There was a marginally significant interaction between Validity * SOA (*F* (3, 54) = 2.501, *p* =

.069), and a marginally significant interaction between Orientation * Validity (*F* (3, 15) = 2.585, *p* = .063), which was qualified by marginally significant interaction between Orientation * Validity * Side (*F* (3, 54) = 2.466, *p* = .072). Although this interaction did not reach the *p* < .05 criteria for statistical significance, it is the most interesting result in terms of the research questions and hypotheses. The interaction was decomposed by a 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within subjects ANOVA for each Orientation (upright and inverted gaze cues) with data collapsed across the Patient and SOA factors (see Figure 19).

The 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within subjects ANOVA for *upright* gaze cues revealed significant main effects of Validity (*F* (2.3, 52.7) = 10.427, *p* < .001) and Side (*F* (1, 23) = 34.060, *p* < .001) which were qualified by an interaction that approached significance Validity * Side (*F* (3, 69) = 2.350, *p* = .080). Bonferroni-corrected comparisons showed that at all levels of Validity ipsilesional targets were detected significantly faster than contralesional targets: Same Location, MD 47ms, *p* < .001; Same Side, MD 50ms, *p* < .001; Opposite Side, MD 42ms, *p* < .001; Neutral, MD 63ms, *p* < .001. The Bonferroni-corrected comparisons also revealed some evidence of location-specific cueing for ipsilesional targets where RTs following Same Location (500ms) cues were significantly faster than RTs following Same Side (512ms; *p* = .042) cues, although there was no significant advantage of Same Location or Same Side cues over Neutral (510ms, both *p*s > .725) cues. RTs following Opposite Side (524ms) cues were slower than RTs following Same Location (*p* = .001), Same Side (*p* = .029) and Neutral (*p* = .054) cues. However, for contralesional targets, Bonferroni-corrected comparisons revealed only one significant difference, which was in RTs between the Same Location (547ms) and Neutral

(573ms, *p* .002) Validity conditions. There were no significant differences in RTs between any other conditions (Same Side 562ms; Opposite Side 566ms; all *p*s > .250).

The 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within subjects ANOVA for *inverted* gaze cues revealed a significant main effect of Side *F* (1, 23) = 38.408, *p* < .001 where ipsilesional targets (507ms) were detected significantly faster than contralesional targets (561ms), but there was no significant main effect of Validity (*F* (3, 69) = 1.213, *p* = .311) and no Validity * Side interaction (*F* (3, 69) = .346, *p* = .792).

Overall, the analysis showed that for upright gaze cues, the patients showed location-specific cueing effects to ipsilesional targets, but only a general effect of cueing for contralesional targets. There were no overall cueing effects associated with the inverted gaze cue, for targets on the patients' ipsilesional or contralesional side.

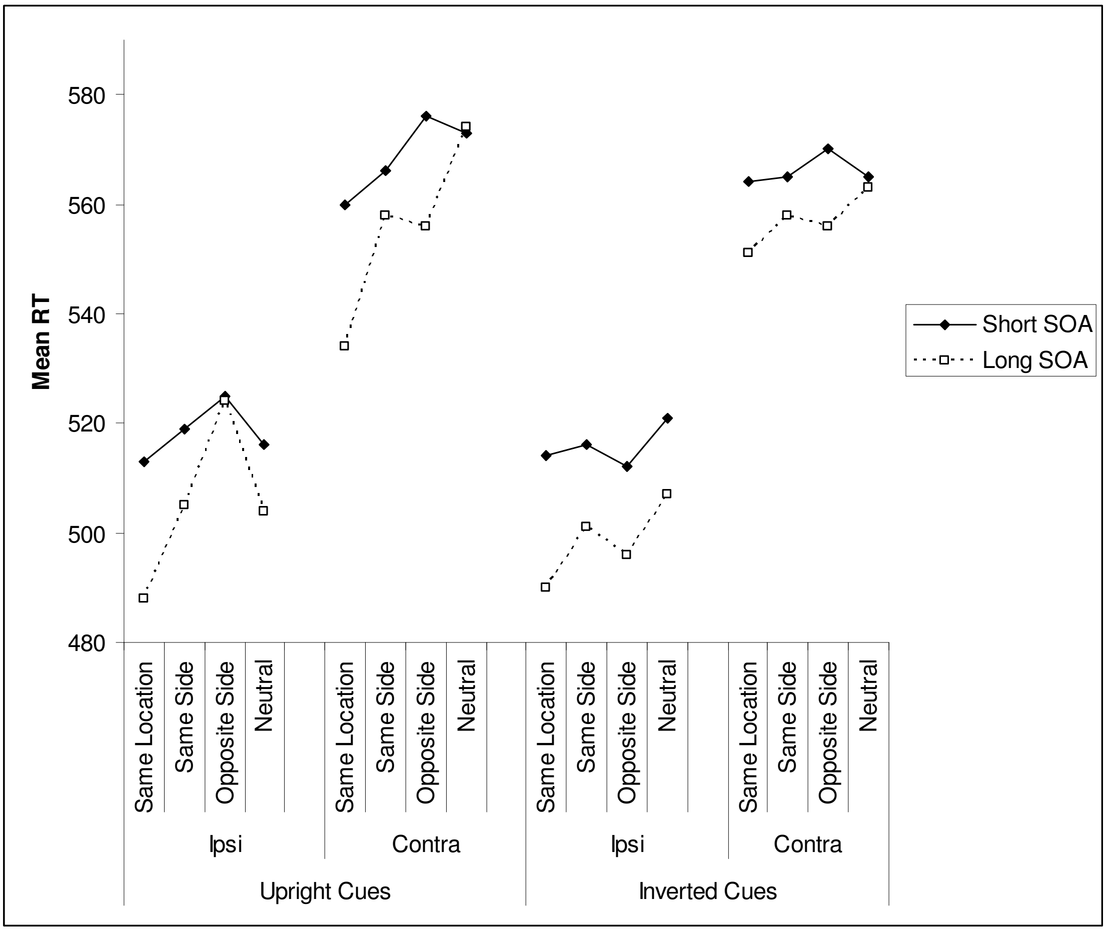

Figure 19. Illustration of data from the parietal-damaged patients in all of the conditions of the upright and inverted gaze experiments.

3.4 Discussion

The results from Experiment 4 largely reflect the results from Experiment 1 in this control group, where there was evidence of location-specific cueing when the realistic gaze cues were upright and when they were inverted. This effect was consistent across both short and long SOAs which showed that attentional reorienting was reflexive. The reflexive gaze cueing effect in controls is not surprising and generally supports the previous findings from gaze cueing studies (e.g. Langton & Bruce, 1999). What is surprising is the relative insensitivity to inversion in our experiment in comparison to the diminished cueing effects of inverted relative to upright gaze reported in previous studies (Langton & Bruce, 1999). This could be due to methodological differences. Here we presented eye gaze shifts in the context of a still face, while Langton & Bruce (1999) use whole head turning gestures to portray gaze shifts. Therefore it is feasible that Langton & Bruce's stimuli demand attention to the face/head gestalt and thus configural processing, whereas our stimuli only require attention to be allocated to the part of the face which provides the cue (i.e. the eye region). The stimuli in the present experiment may be processed in a more efficient parts-based manner regardless of cue orientation, since facial details (other than the eyes) were irrelevant to the task. This is consistent with a study by Jenkins and Langton (2003) who showed that inversion of the face cue had no effect on gaze direction judgements, both under conditions when the eyes remained upright within the inverted face, and when the eyes too were inverted (as per our inverted gaze cue). Kingstone et al. (2000) have also shown that gaze processing is influenced to some extent by facial identity (via disrupted gaze cueing following face inversion) they also showed that attention to gaze is not entirely dependent on face processing (as gaze cueing effects were still evident when the eyes were presented alone). Thus we propose that since the face cues provided no additional directional to the gaze shift, these were ignored over the course of the experiment, and hence gaze was attended to independently of the face context.

For the parietal-damaged patient group, the analysis showed some evidence of location-specific cueing effects of upright gaze cues for ipsilesional targets, where being cued to the same location had significant benefits for target detection in relation to being cued to a different location on the same side. However, there was actually no benefit to either of these cue conditions in relation to the neutral cue. This pattern of orienting could reflect a strategic response whereby the ipsilesional side is automatically attended to in the absence of a directional cue. The story is simpler for contralesional targets, as there was a general advantage to being cued to the correct location over not being cued at all (i.e. in the neutral condition), which is consistent with the cueing effect found with schematic gaze cues in Experiment 1. However, conversely to the results of Chapter 1, the patient group showed no significant validity effects in response to the inverted gaze cue.

The data from controls shows, at the very basic level, that presenting the eye gaze cue in the canonical or inverted orientation allows a shifting of attention more accurately to target locations in accordance with the gaze direction of another person, which supports the findings of Tipple (2005). However, in conditions where spatial orienting is impaired (such as visual extinction), patients are unable to make sense of the inverted gaze cue to shift their own attention in either direction. This effect demonstrates that inversion of a realistic face may result in a loss of some social meaning but retention of low level directional cueing properties of gaze shifts (Kingstone et al, 2000). In normal viewers, an inverted cue can be used to also shift attention reflexively as shown for symbolic arrow cues (Tipples, 2002) thus making the effect indistinguishable from the ‘socially relevant’ cueing of the upright holistic face cue. However, when the face loses its social meaning through inversion for the patient group, they cannot use the residual directional properties of gaze shifts to direct their attention to targets on either side.

Experiment 5: Upright vs. Inverted Realistic Pointing 'Across the Body' Cues

Methods

3.5.1 Materials

The central stimulus was presented so as to be as close as possible in size to the outstretched pointing image in Experiment 2 (see section 2*.5.1 Materials*). A model posed with a neutral facial expression while photographs were taken of the upper body with the arms resting by the sides, and across the body towards the upper and lower positions on each side of the body. That is, the *left* arm was pointed across the torso in a pointing gesture towards the upper and lower *right* corners of the room, and similarly the *right* arm pointed across the body towards the *left* corners (see

Figure 20). Care was taken to match the visual angles of the pointing stimuli in Experiment 2. The arms were all masked onto the same basic torso image, so that the only change between each image was the position of the arms, and not subtle shifts in body position, for example. All pointing images were resized to fit a virtual 6cm*4cm rectangle, so that they closely matched the images presented in Experiment 2. The images appeared centrally on the computer screen, and the target dimensions and positions were the same a those described in Experiment 1 (see Chapter 2 section *2.5.1 Materials*). The materials for the inverted cue were the same except that the central cue was rotated through 180°, so that it was upside-down.

Figure 20. An example of an invalid Opposite Side upright pointing across the body cue.

3.6 Results

Each control contributed 20 raw data points (RTs) per condition in each experiment. Misses and anticipatory responses (<100ms) were removed from further analyses (0.16% of total dataset). Within each condition per session, RTs outside of 2 SDs of the mean were removed (6.07% of total dataset) and a mean RT was calculated from the remaining data for each experiment. Each patient contributed 20 raw data points (RTs) per condition in each experiment. Misses and anticipatory responses (<100ms) were removed from further analyses (3.89% of total dataset). Within each condition, RTs outside of 2 SDs of the mean were removed (7.03% of total dataset) and a mean RT was calculated from the remaining data for each condition in each experiment.

3.6.1 Controls vs. Patients – Ipsilesional Targets

The analysis showed no effect of Group (*F* (1, 14) = 1.052, *p* = .322), but significant main effects of Orientation (*F* (1, 14) = 4.661, *p* = .049; Upright cues 461ms, Inverted cues 475ms), Validity (*F* (3, 42) = 9.981, *p* < .001) and SOA (*F* (1, 14) = 12.998, *p* = .003; short 474ms, long 462ms;

see Figure 21). Bonferroni-corrected comparisons showed no evidence of location-specific cueing (Same Location 459ms vs. Same Side 464ms, *p* = .364), rather a general cueing towards the correct side (Same Location 459ms vs. Opposite Side 473ms, *p* = .016; Same Side 464ms vs. Neutral 476ms, *p* = .039).

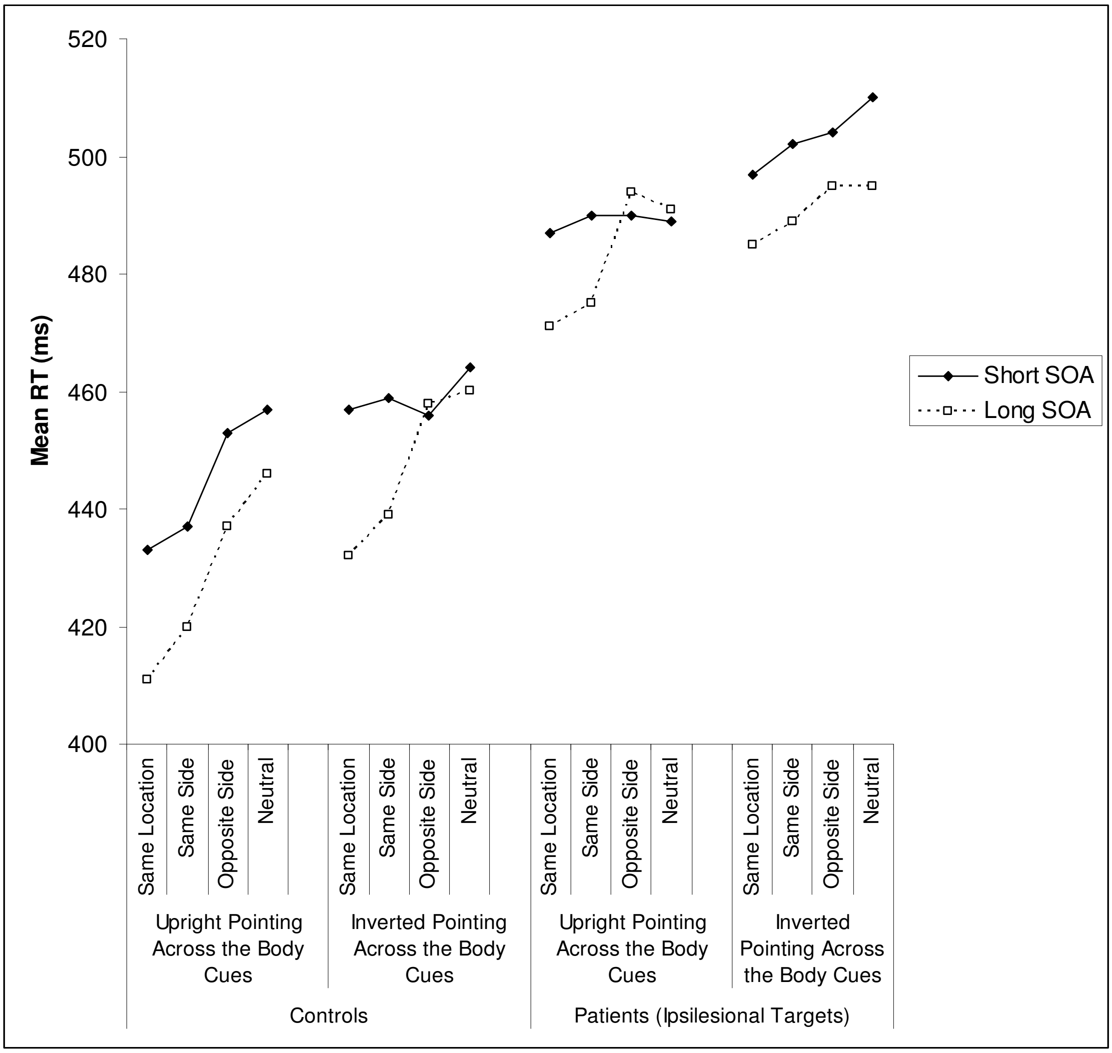

Figure 21. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (ipsilesional targets) in the Upright and Inverted Pointing 'Across the Body' cue experiments.

3.6.2 Controls vs. Patients – Contralesional Targets

The analysis showed significant main effects of both Group (*F* (1, 14) = 4.628, *p* = .049; Controls 445ms, Patients 535ms) and Orientation (*F* (1, 14) = 6.168, *p* = .026; Upright cues 480ms, Inverted cues 499ms). There were significant main effects of Validity (*F* (3, 42) = 6.131, *p* = .001) and SOA (*F* (1, 14) = 16.197, *p* = .001; short SOA 498ms, long SOA 482ms). Bonferroni-corrected comparisons between Validity conditions showed no location-specific cueing effects, with the only significant difference in RTs being between Same Location (481ms) and Neutral (500ms, *p* = .021) cues. No other differences in RTs between validity conditions were significant (Same Side 488ms, Opposite Side 491ms; all *p*s > .060). The main analysis also revealed a significant interaction between Orientation * SOA * Group (*F* (1, 14) = 5.292, *p* = .037; see Figure 22) which was broken down into separate 2 (Orientation: Upright, Inverted) * 2 (SOA: short, long) within-subjects ANOVAs for each Group (Controls, Patients). For the controls, there were significant main effects of Orientation (*F* (1, 9) = 7.450, *p* = .023; Upright cues 437ms, Inverted cues 442ms) and SOA (*F* (1, 9) = 9.301, *p* = .014; short SOA 48ms, long SOA 431ms) but no interaction (*p* > .700). For the patients, there was a marginal effect of Orientation (*F* (1, 9) = 4.889, *p* = .078; Upright cues 524ms, Inverted cues 531ms), but no effect of SOA or interaction (both *p*s > .210).

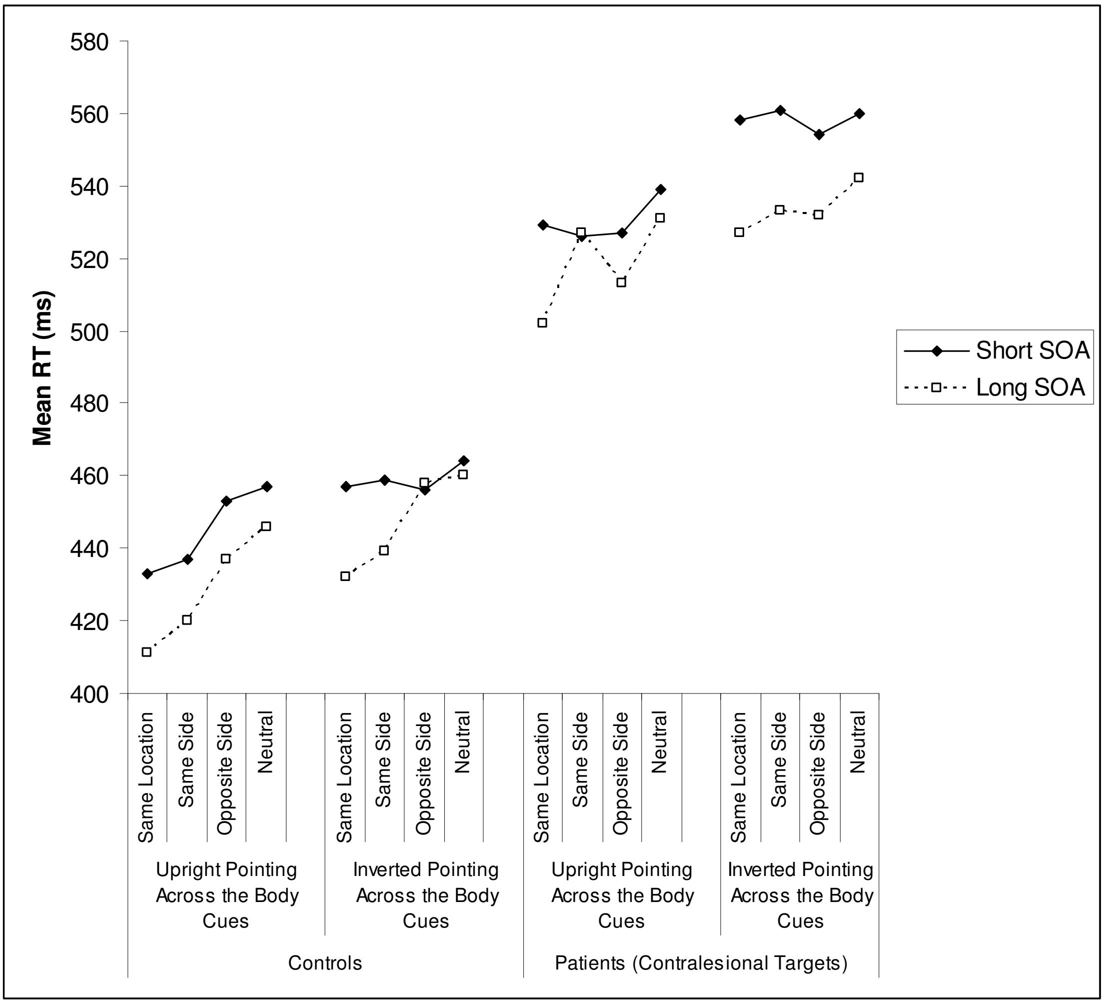

Figure 22. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (contralesional targets) in the Upright and Inverted Pointing 'Across the Body' cue experiments.

3.6.3 Parietal-Damaged Patients

The analysis revealed no significant main effect of Orientation (*F* (1, 18) = 1.769, *p* = .200), and no interaction between Orientation * Patient (*F* (5, 18) = .755, *p* = .593). There was a significant main effect of Validity (*F* (3, 54) = 6.930, *p* < .001), which interacted with other factors as follows: Validity * Patient (*F* (15, 54) = 4.517, *p* < .001); Validity * Side * Patient (*F* (15, 54) =

1.826, *p* = .055). There was a significant interactions between Side * SOA * Patient (*F* (5, 18) = 12.817, *p* < .001). Although there was no significant main effect of Orientation, this did interact with other factors as follows: Orientation * SOA *F* (1, 18) = 6.623, *p* = .019, Orientation * Side (*F* (1, 18) = 4.203, *p* = .055) and Orientation * Validity * Patient (*F* (15, 54) = 2.321, *p* = .012; see Figure 23).

The most interesting interactions in terms of the hypotheses are Orientation * SOA and Orientation * Side, but since Orientation also interacts with Validity and Patient factors, the interactions will be explored further in a 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: 100ms, 300ms) * 6 (Patient: DB, DT, JB, MH, PF, RP) mixed design ANOVA for each Orientation (Upright and Inverted).

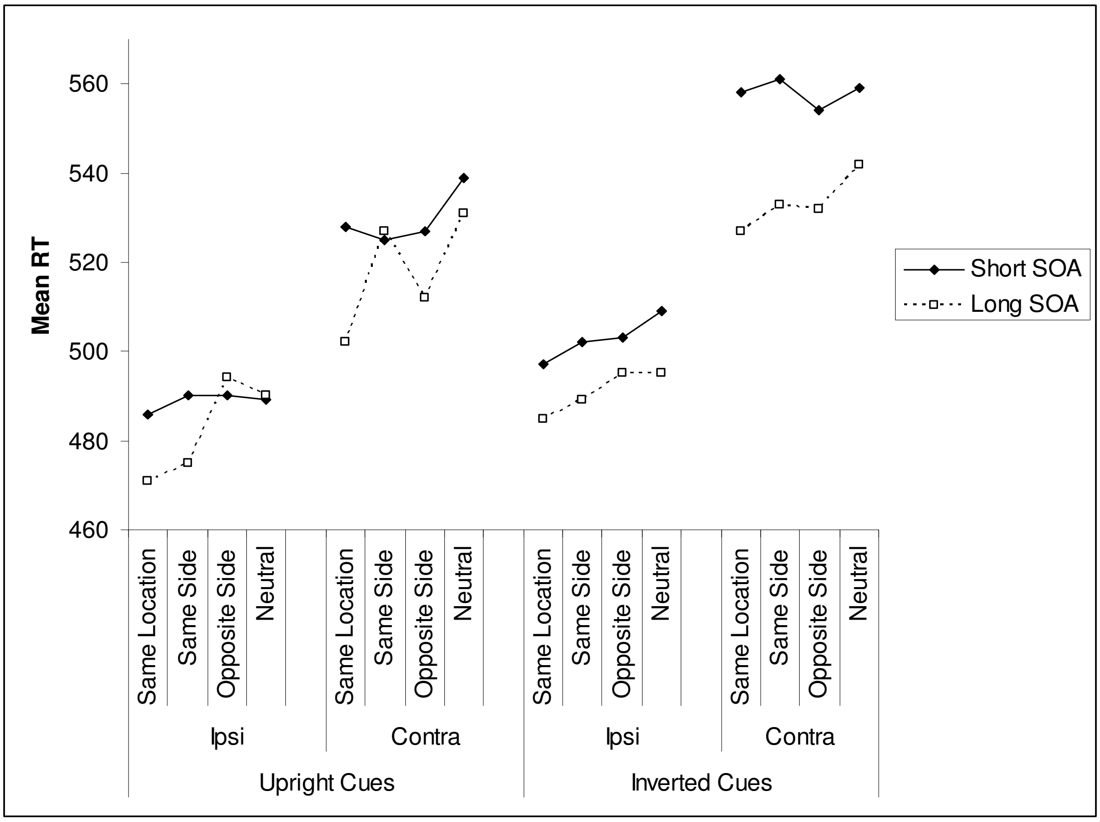

Figure 23. Illustration of data from the parietal-damaged patients in all of the conditions in the upright and inverted pointing across the body experiments.

The 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: 100ms, 300ms) * 6 (Patient: DB, DT, JB, MH, PF, RP) mixed design ANOVA for the *upright* point across the body cues revealed many significant effects (see Table 4) that were qualified by a significant three-way interaction between Validity * Side * SOA (F (3, 54) = 3.136, p = .033) with no interaction from the patient factor (p > .100), so this was decomposed into separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 Side (ipsilesional, contralesional) ANOVAs for each SOA (short, long) with data collapsed across the patient factor.

Table 4. A summary of all statistically significant results from the 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: 100ms, 300ms) * 6 (Patient: DB, DT, JB, MH, PF, RP) mixed design ANOVA for the *upright* point across the body cues.

Factors	**Statistical Result**
Validity	F (3, 54) = 7.333, $p < .001$
Validity * Patient	F (15, 54) = 3.368, $p < .001$
Side	F (1, 18) = 66.778, $p < .001$
Side * Patient	F (5, 18) = 18.232, $p < .001$
SOA	F (1, 18) = 11.896, $p = .003$
SOA * Patient	F (5, 18) = 4.604, $p = .007$
Validity * Side	F (3, 54) = 4.763, $p = .005$
Validity * Side * Patient	F (15, 54) = 2.350, $p = .011$
Validity * SOA	F (3, 54) = 3.590, $p = .019$
Side * SOA * Patient	F (5, 18) = 8.060, $p < .001$

For the short SOAs, the 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within subjects ANOVA revealed a significant main effect of Side (F (1, 23) = 14.802, $p = .001$; ipsilesional target detection: 489ms; contralesional target detection: 530ms), but no effect of Validity (F (3, 69) = .630, $p = .598$) and no interaction (F (3, 69) = .882, $p = .455$). This shows that the previous three-way interaction was driven by differing validity effects at each target side following the long SOA.

Indeed, for the long SOAs, the 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) within subjects ANOVA revealed significant main effects of Validity (*F* (3, 69) = 8.996, $p < .001$) and Side (*F* (1, 23) = 10.892, $p = .003$) which were qualified by a significant interaction (*F* (3, 69) = 6.683, $p = .001$). This interaction can be seen quite clearly in Figure 23, where the pattern of RTs across the Validity conditions is visibly different for ipsilesional and contralesional target detection following Long SOAs. Bonferroni-corrected comparisons reveal that for ipsilesional targets, there was no significant difference between RTs following Same Location and Same Side cues (MD 4ms, $p > .999$) nor between RTs following Opposite Side and Neutral cues (MD 3ms, $p < .999$). However, Same Location and Same Side cues elicited significantly faster RTs than Opposite Side and Neutral cues (all *p*s < .05). This shows that there was no location-specific cueing effect for ipsilesional targets following the long SOA, but the effect was limited to a general advantage for being cued to the correct side of the target.

However, for contralesional targets, Bonferroni-corrected comparisons revealed that Same Location cues elicited significantly faster RTs than Same Side cues (MD 26ms, $p = .001$) and Neutral cues (MD 30ms, $p = .002$), and there was no significant difference in RTs following Same Side and Neutral cues (MD 4ms, $p > .999$). This pattern of RTs seems to be indicating an effect of location-specific cueing, but the pattern of RTs following the Opposite Side cue relative to the other validity conditions is rather strange here. There is no significant difference in RTs between the Opposite Side and Same Location (MD 11ms, $p = .641$), Same Side (MD 15ms, $p = .272$) or Neutral (MD 19ms, $p > .05$) validity conditions.

The 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: 100ms, 300ms) * 6 (Patient: DB, DT, JB, MH, PF, RP) mixed design ANOVA for the *inverted* point across the body cues revealed a marginally significant effect of Validity (*F* (3, 54) = 2.500, $p = .069$) which interacted with the patient factor

Validity * Patient (*F* (15, 54) = 3.837, *p* < .001), a significant main effect of Side (*F* (1, 18) = 416.273, *p* < .001), which also interacted with the patient factor Side * Patient (*F* (5, 18) = 47.525, *p* < .001), and a significant main effect of SOA *F* (1, 18) = 36.202, *p* < .001 which interacted with Side: SOA * Side (*F* (1, 18) = 6.169, *p* = .023). The Side * SOA interaction was explored further with Bonferroni-corrected comparisons, which revealed that RTs are significantly faster for ipsilesional than contralesional target detection following both the short (MD 55ms, *p* < .001) and the long SOAs (45ms, *p* < .001). However, the cause of the interaction appears to be due to significantly faster RTs following a long SOA than a short SOA for both ipsilesional (MD 12ms, *p* = .004) and contralesional (MD 25ms, *p* < .001) target detection, where the effect is stronger for the latter and this can be seen clearly in Figure 23.

As can be seen from Figure 23, there is much less fluctuation in the pattern of RTs across the validity conditions for each side when the cues were inverted than for when they were upright. The interactions with the patient factor demonstrate that some patients were showing stronger effects of validity and side than others. Bonferroni-corrected comparisons between validity conditions (across patients, side and SOA) that there was no significant advantage in RTs of being cued to the Same Location (507ms) over the Same Side (513ms, *p* = .114), although Same Location cues elicited marginally faster RTs than Opposite Side cues (513ms, *p* = .080) and significantly faster RTs than Neutral cues (519ms, *p* = .002). Same Side cues elicited marginally faster RTs than Neutral cues (MD 6ms, *p* = .057), but all other differences in RTs between the validity conditions were not significant (all *p*s > .550).

The analysis of the data from the upright and inverted ‘across the body’ pointing cues showed no validity effects for either side following to short SOA nor the long SOA. However, the lack of difference in RTs between Same Location and Opposite Side cue conditions for contralesional target detection may be due to the central figure pointing across his body (i.e. points with his left arm to his right side) which may cause confusion as to which side of space is being cued. This will be explored further in the discussion section.

3.7 Discussion

For the pointing across the body cues in the control group, there was no evidence of location-specific cueing whether the body-cue was presented upright or inverted. For the upright cues, there was a general shift of attention to the correct side of space in relation to neutral cues, across the SOAs, which is indicative of reflexive orienting. For the inverted cues, the general cueing effect to the correct side was only present following a long SOA, which is reminiscent of voluntary, endogenous orienting mechanisms. This cue was developed to be closely matched in terms of motion to the eye gaze cue, due to the large apparent motion associated with the previous pointing cue, and yet does not show the same validity effects as either of these cues. This could be because the social relevance of gaze allows normal observers to be cued to specific locations within another person's visual field (Vuilleumier, 2002), and this social relevance does not extend to pointing gestures. Indeed, the general cueing to the correct side is very similar to the effect of the symbolic arrow reported in the control group in Chapter 2 (Experiment 3), suggesting that pointing gestures are symbolic rather than social in nature.

Similarly for the patients' ipsilesional target detection, the upright pointing cues produced no location-specific cueing effect, but a general shift of attention to that side of space. For contralesional targets there was a confusing pattern of validity effects where there appeared to be no cost of being invalidly cued to the opposite target location in relation to being cued validly to the correct location. This effect is difficult to explain, but may be due to the pictured man gesturing with the left arm towards a right side target, and vice versa, which may cause confusion to the viewer with regards to which side of space is being cued. However, if this were a valid hypothesis for the pattern of validity effects described here, then we should expect a similar effect when the cue is inverted. Indeed for inverted pointing across the body cues, there was no evidence of location-specific cueing to either ipsilesional or contralesional targets. Since being cued to the correct location has no significant benefit as compared to being cued to the incorrect location on the opposite side, we cannot argue that the shift in attention is location-specific, nor is it specific to a general side of space in the patient group. Therefore it must be concluded that for this group of parietal-damaged patients, there are no reliable validity effects of the upright pointing across the body cues for contralesional target detection. Since the general shift of attention to the correct side in the control group took longer to emerge when the cue was inverted, this supports the explanation that the cue was relatively confusing in terms of the directionality it depicted. Therefore, in our quest to create a cue that could be equated to gaze shifts in terms of motion and proximity to target locations, we may have created greater ambiguity in this cue than any others presented in this series of experiments. Nevertheless, the social nature of pointing hand cues (Experiment 6) can be assessed by comparison to the validity effects of the symbolic arrow cues in the previous Chapter (Experiment 3).

Experiment 6: Realistic Pointing Hand Cues

Methods

3.8.1 Materials

A model positioned their hand into a pointing gesture, while photographs were taken against a white background. The pointing hand image was resized to fit a virtual 6cm*4cm rectangle, so that it closely matched the size of the central stimuli in the previous experiments in this Chapter. It was not possible to match the hand stimulus to the size of the Arrow in Experiment 3, as at this size (2cm * 0.8cm) it was not easily recognised as a human hand. Therefore it was best to match the hand cue in size to the stimuli in Experiments 4 and 5 for more accurate comparison of results later. The image was rotated in Adobe® Photoshop® CS2 so that the hand pointed towards all target locations (at the same visual angles as the arrow in Experiment 3) and pointed straight upwards for the 'neutral' condition (see Figure 24). The pointing hand images appeared centrally on the computer screen, and the target dimensions and positions were the same a those described in Experiment 1 (see Chapter 2 section *2.2.4 Materials*).

Figure 24. An example of a neutral pointing hand cue.

3.9 Results

Each control contributed 20 raw data points (RTs) per condition in each experiment. Misses and anticipatory responses (<100ms) were removed from further analyses (0.18% of total dataset). Within each condition per session, RTs outside of 2 SDs of the mean were removed (5.99% of total dataset) and a mean RT was calculated from the remaining data for each experiment. Each patient contributed 20 raw data points (RTs) per condition in each experiment. Misses and anticipatory responses (<100ms) were removed from further analyses (2.99% of total dataset). Within each condition, RTs outside of 2 SDs of the mean were removed (7.17% of total dataset) and a mean RT was calculated from the remaining data for each condition in each experiment.

3.9.1 Controls vs. Patients – Ipsilesional Targets

The analysis showed no effect of Group (F (1, 14) = .946, p = .347), but significant main effects Validity (F (3, 42) = 27.591, p < .001) and SOA (F (1, 14) = 17.972, p = .001; short 481ms, long 467ms; see Figure 25). Bonferroni-corrected comparisons between the Validity conditions showed evidence of location-specific cueing, as RTs were faster for Same Location cues (448ms) than Same Side cues (473ms, $p < .001$). There was no difference in RTs between Same Side (472ms) and Opposite Side (482ms, $p = .436$) cues, indicating that orienting was the same within and between hemifields.

All of these comparisons show that there was no significant difference in the pattern of performance between the control group and patients ipsilesional target detection. This shows that patients process each of the cues in a 'normal' way and use the gaze and pointing cues to direct their attention accordingly to targets which appear on their ipsilesional 'good' side.

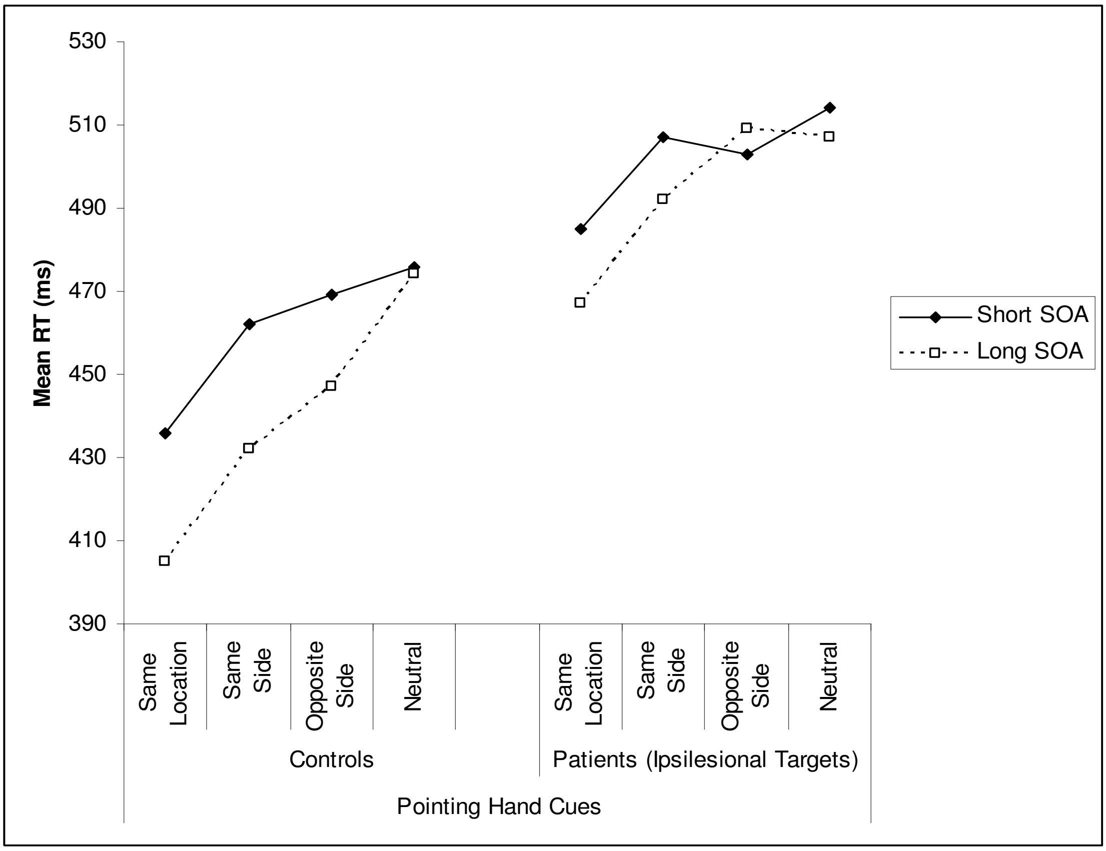

Figure 25. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (ipsilesional targets) in the Pointing Hand cue experiment.

3.9.2 Controls vs. Patients – Contralesional Targets

The analysis showed a marginal effect of Group (*F* (1, 14) = 3.388, *p* = .087; Controls 450ms, Patients 537ms). There were significant main effects of Validity (*F* (3, 42) = 26.707, *p* < .001) and SOA (*F* (1, 14) = 23.621, *p* < .001) which were qualified by an interaction (*F* (3, 42) = 4.516, *p* = .008; see Figure 26). Bonferroni-corrected comparisons between the Validity conditions showed a marginal effect of location specific cueing at the short SOA (Same Location 481ms, Same Side 501ms, *p* = .060), although this effect was highly significant at the long SOA (Same Location 451ms, Same Side 482ms, *p* = .005).

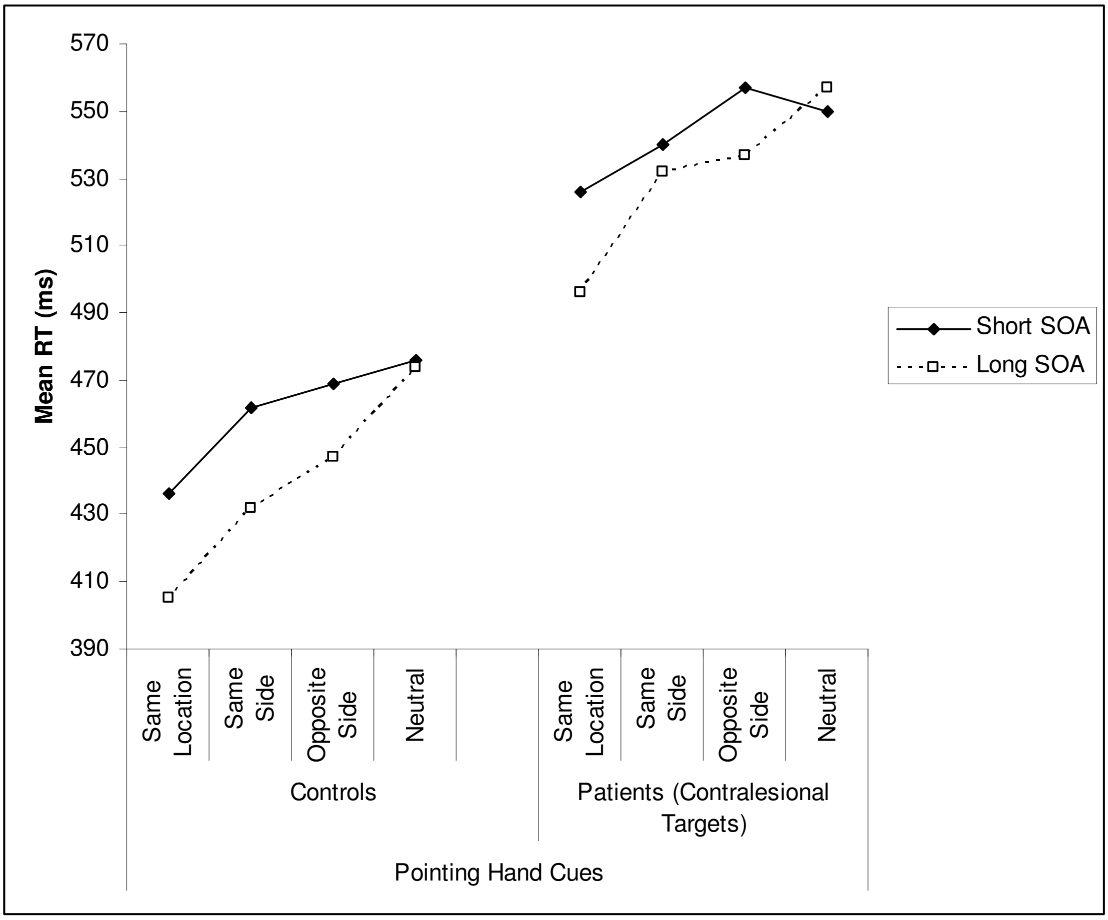

Figure 26. Illustration of Validity effects at both SOAs for the controls (collapsed across Side) and the parietal-damaged patients (contralesional targets) in the Pointing Hand cue experiment.

3.9.3 Parietal-Damaged Patients

The analysis revealed significant main effects of Validity (*F* (1.8, 32.2) = 31.287, *p* < .001), Side (*F* (1, 18) = 100.055, *p* < .001), and SOA (*F* (1, 18) = 12.079, *p* = .003). There were significant interactions between Side * Patient (*F* (5, 18) = 19.132, *p* < .001), Validity * SOA (*F* (2.1, 38.6) = 3.663, *p* = .032), and Validity * Side * Patient (*F* (10.4, 37.5) = 12.079, *p* < .001). The patient interactions occur due to patients showing different magnitudes in their effect of side, owning to differences in the severity of visual extinction, so the patient interactions were not explored further. However, since there were interactions involving Validity * SOA and Validity * Side, these interactions were decomposed into separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) ANOVAs each Side (ipsilesional, contralesional) with data collapsed across patients (see Figure 27).

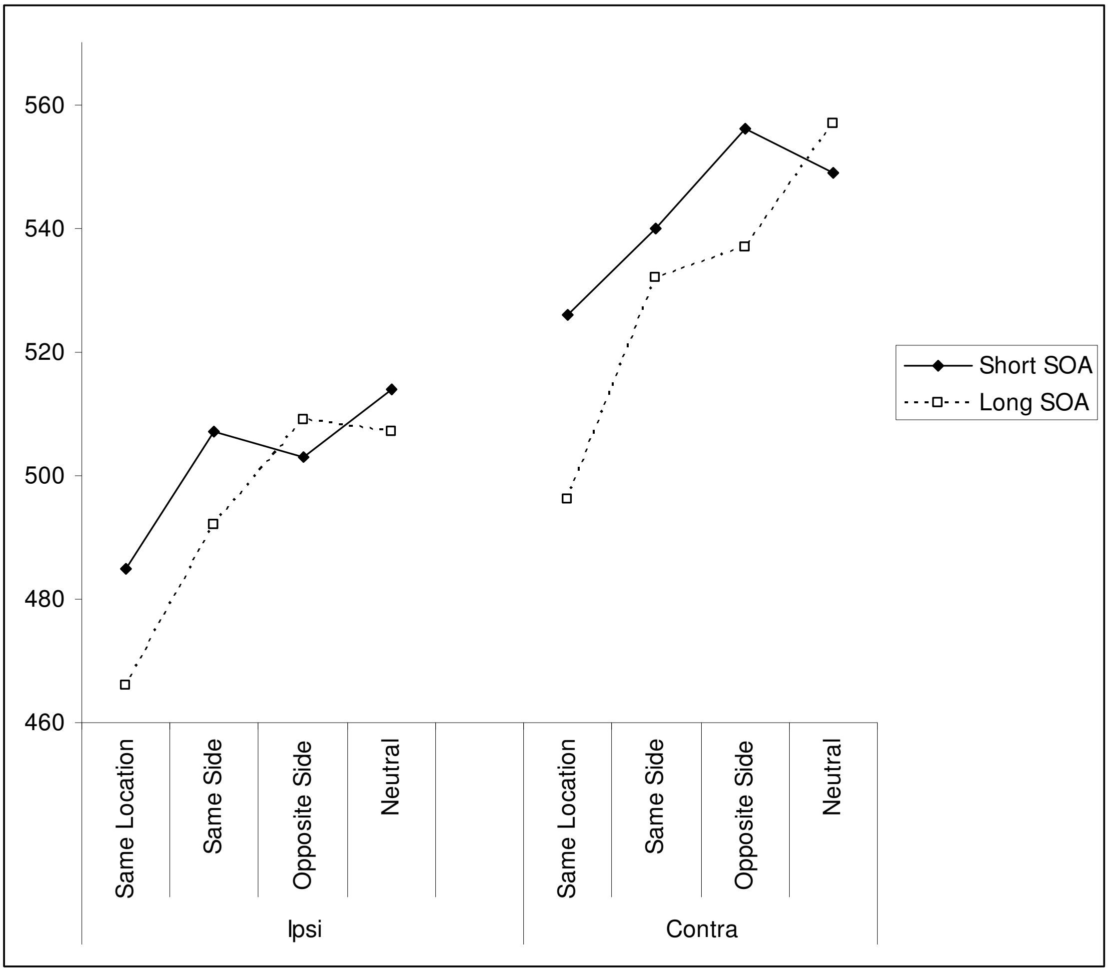

Figure 27. Illustration of data from the parietal-damaged patients in all of the conditions in the pointing hand experiment.

For ipsilesional targets, the ANOVA revealed significant main effects of Validity (*F* (3, 69) = 17.682, *p* < .001) and SOA (*F* (1, 23) = 5.616, *p* = .027) which were qualified by an interaction (*F* (3, 69) = 2.878, *p* = .042). Bonferroni-corrected comparisons between validity conditions for the short SOA showed that Same Location cues (485ms) elicited significantly faster RTs than Same Side (507ms, *p* = .009), Opposite Side (503ms, *p* = .037) and Neutral (514ms, *p* < .001) conditions. However, there was no significant difference between RTs in the Same Side, Opposite Side and Neutral conditions (*p* > .999). The Bonferroni-corrected comparisons between validity conditions at the long SOA showed the same pattern of results as for the short SOA. That is, Same Location cues (466ms) elicited significantly faster RTs than Same Side (492ms, *p* = .002), Opposite Side (509ms, *p* < .001) and Neutral (506ms, *p* < .001) conditions, but there was no significant difference between RTs in the Same Side, Opposite Side and Neutral conditions (*p* > .2).

For contralesional targets, the ANOVA revealed significant main effects of Validity (*F* (3, 69) = 13.213, *p* < .001) and SOA (*F* (1, 23) = 7.486, *p* = .012) which were qualified by an interaction (*F* (3, 69) = 3.015, *p* = .036). For the short SOA Bonferroni-corrected comparisons showed very little difference between the validity conditions, where the only significant difference in RTs was between Same Location (526ms) and Opposite Side (556ms, *p* = .040) conditions. There was no significant difference in RTs following Same Location and Same Side (540ms, *p* = .424) cues, and no other differences approached significance (all *p*s > .1). However, following the long SOA, Bonferroni-corrected comparisons showed that Same Location cues (496ms) elicited significantly faster RTs than Same Side (532ms, *p* = .017), Opposite Side (537ms, *p* = .001) and Neutral (557ms, *p* < .001) cues. There were no other differences in RTs between conditions which approached significance (*p* > .5).

3.10 Discussion

For the control group, there were location-specific cueing effects across the SOAs in response to the pointing hand cues, which is consistent with a reflexive orienting response. The analyses of the patient data from the pointing Hand cue experiments showed that for ipsilesional targets, the cueing effects was location-specific across SOAs, as observed in the control group. However, for contralesional target detection, the location-specific cueing effect was only seen at the long SOA. Therefore, orienting in response to the pointing Hand cue was reflexive in both directions, but the location specific effects took longer to emerge in the contralesional direction. This is consistent with Vuilleumier's (2002) proposal that while orienting generally to one side of space occurs reflexively, location-specific effects are generally seen later (i.e. after about 250ms). However, our finding of location-specific cueing effects at short SOAs for controls suggests that the hand cues operate to shift attention in the same way as gaze cues. Furthermore, the pointing hand cues offer more accurate (i.e. location specific) cueing effects than symbolic arrows (i.e. general shifting of attention to one side; see Chapter 2), thus supporting our claim that pointing gestures do have a social significance, and as such attention is oriented more accurately in response to these cues than purely directional symbolic cues.

3.11 Cross-Experiment Analyses

To investigate differences in the magnitude of validity effects between the cues, separate analyses were carried out between the types of cues. To find out whether the pointing hand cue elicits the same validity effects as when the pointing cue is presented in the context of a human body, data from the upright subtle pointing cue experiment were analysed alongside data from the pointing hand cue experiment (see 'Exploring Effects of Different Pointing Gestures' below). To explore the potential differences in the validity effects associated with gaze and subtle full-body pointing cues, these were also compared directly in a further analysis (see 'Comparing Validity Effects of Gaze Cues vs. Pointing Cues' below). Since we are interested in relative validity effects of the two types of cue, the data have been collapsed across the patient factor in order to compare against the control group and investigate the cue type by validity effects that are the main question here. All other effects and interactions have been reported in detail in the previous sections so will not be repeated in the following sections. The results of these cross-experiment analyses will be provided in the Main Discussion at the end of this Chapter.

Exploring Effects of Different Pointing Gestures

The following analysis was carried out to compare the relative validity effects of the subtle full-body pointing gesture and the pointing hand gesture, to investigate possible differences in the processing of the pointing cue in the context of a human body (pointing) and in isolation (hand cue) between the age-matched controls and the parietal-damaged patients, separately for ipsilesional and contralesional target detection. Data were entered into a 2 (Group: Controls, Patients) * 2 (Cue type: Hand cue, Upright Pointing cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA, separately for patients ipsilesional and contralesional target trials.

Controls vs. Patients – Ipsilesional Targets

The analysis revealed no significant main effect of Group ($p > .438$) or Cue Type ($p > .100$) but a significant Cue Type * Validity interaction (F (3, 42) = 3.969, $p = .014$; see Figure 28). Bonferroni-corrected comparisons showed that RTs were significantly faster for the pointing Hand cue (482ms) than Pointing cues (511ms) in the Opposite Side validity condition only ($p =$ .035; all other ps > .075). There was evidence of location-specific cueing for both cues, which has been described in detail in previous sections. The interaction is driven by a significant difference in RTs between Same Side (497ms) and Opposite Side (511ms) cues for the Pointing cues (*p* = .005) but not for the Hand cues (*p* = .436), and a significant difference in RTs between Same Side (473ms) and Neutral (492ms) cues for the Hand cues (*p* = .003) but not for the Pointing cues (*p* = .116). There were also significant effects of Validity, SOA and Validity * SOA (all *p*s < .005), but these have been reported in detail in the previous sections so will not be repeated here.

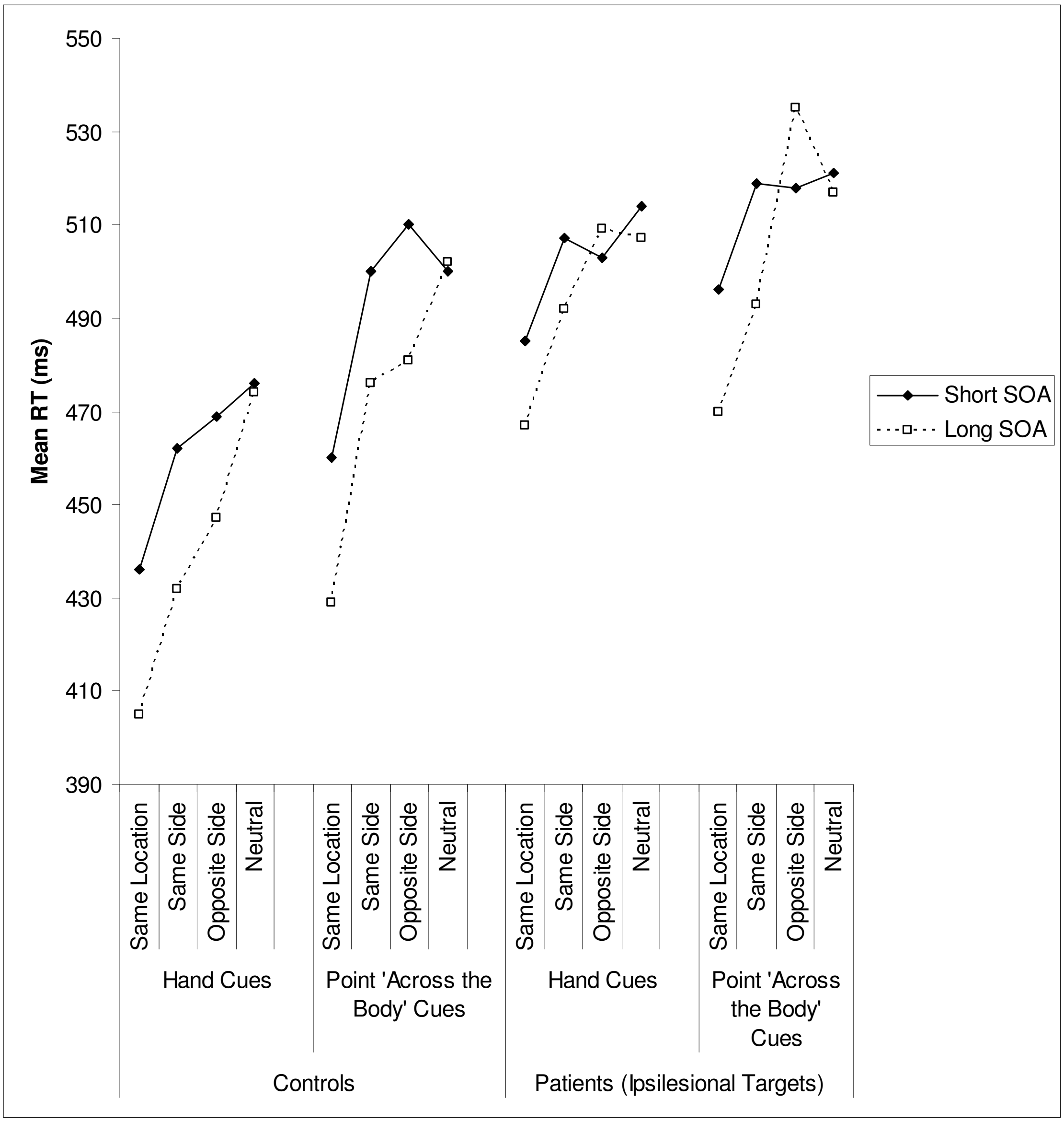

Figure 28. Illustration of Validity effects in the Hand and upright Pointing cues between the age-matched controls (collapsed across side) and patients' ipsilesional target detection.

Controls vs. Patients – Contralesional Targets

The analysis revealed marginal effects of Group (*F* (1, 14) = 3.131, *p* = .099; Controls 466ms, Patients 543ms) and Cue Type (*F* (1, 14) = 3.455, *p* = .084; Pointing 516ms, Hand 493ms).

There were also significant effects of Validity, SOA and Validity * SOA (all *p*s < .005), but these have been reported in detail in the previous sections so will not be repeated here. The interaction of interest to this section is the significant Cue Type * Validity interaction (*F* (3, 42) = 4.982, p = .005; see Figure 29). Bonferroni-corrected comparisons showed faster RTs for Hand cues than Pointing cues in the Same Side (MD 29ms, p = .042) and Opposite Side (MD 31ms, p = .023) conditions. There was evidence of location-specific cueing for both Cue Types with the same pattern of Validity effects for both cues, with the exception of a significant difference between Same Side (492ms) and Neutral (514ms, p = .001) for Hand cues, but this difference was not significant for Pointing cues (MD 10ms, p = .359).

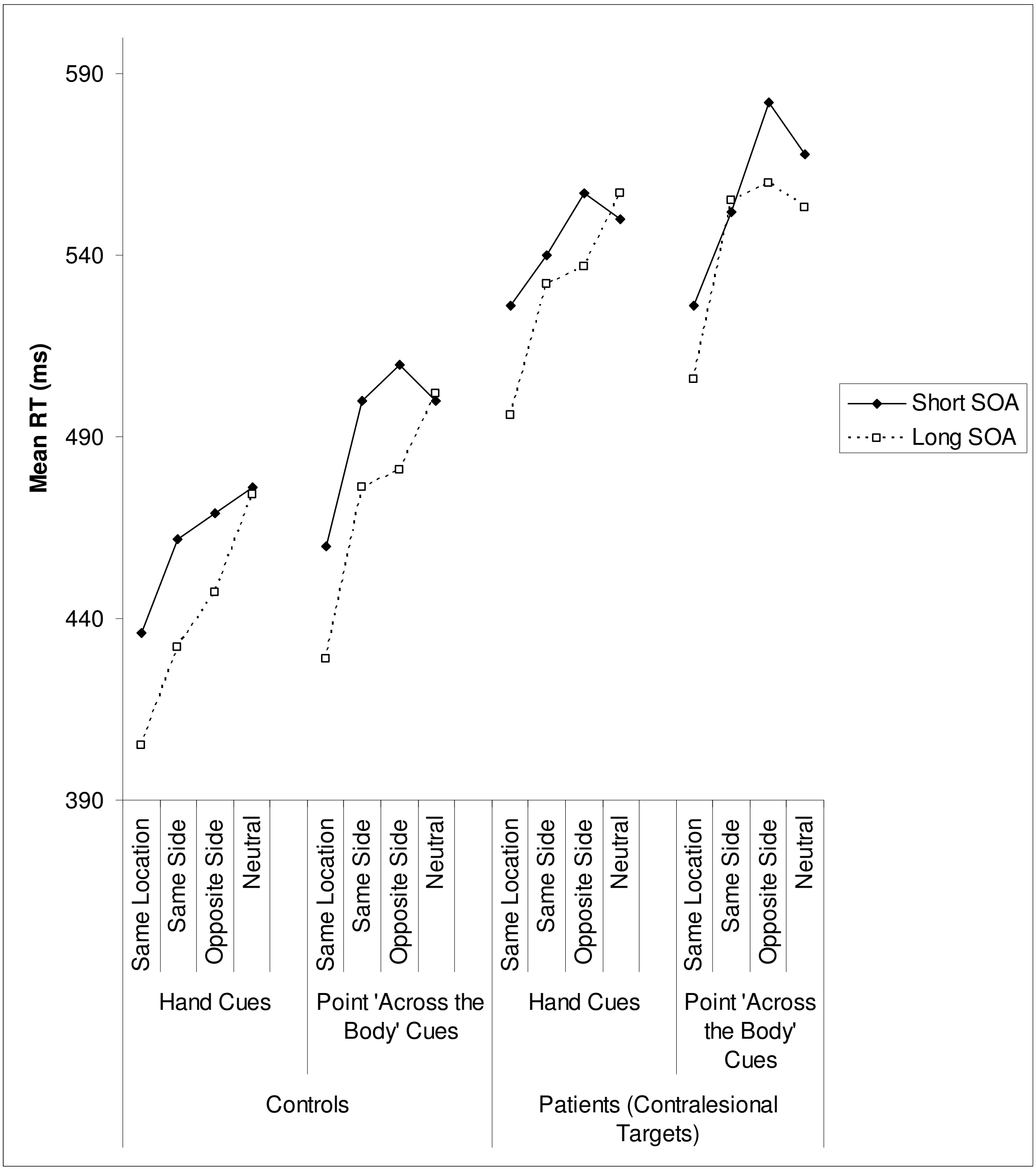

Figure 29. Illustration of Validity effects in the Hand and upright Pointing cues between the age-matched controls (collapsed across side) and patients' contralesional target detection.

Comparing Validity Effects of Gaze Cues vs. Pointing Cues

One of the main purposes of this series of experiments was to investigate the possibility of different processes involved in the orienting of attention following gaze shifts and pointing gestures. The following analysis compares the effects of the upright gaze cues with the upright subtle pointing cue, between the age-matched controls and parietal-damaged patients, separately for ipsilesional and contralesional target trials. Data for both analyses were entered into a 2 (Group: Controls, Patients) * 2 (Cue type: Upright Gaze cue, Upright 'Point Across the Body' cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA separately for patients ipsilesional and contralesional target trials.

Controls vs. Patients – Ipsilesional Targets

The analysis showed no main effect of Group ($p > .210$) or Cue Type ($p > .095$). There were significant effects of Validity and SOA (both *p*s < .002), but these have been reported in detail in the previous sections so will not be repeated here. Unlike previous analyses, the interaction between Cue Type and Validity did not reach significance ($p > .075$), and Bonferroni-corrected comparisons showing location-specific cueing effects across Group, Cue Types and SOAs (Same Location 458ms, Same Side 466ms, $p = .025$), with no significant difference in RTs between Same Side (466ms) and Neutral (475ms, $p = .234$) conditions, further supporting that the cueing effect was not general to one side (see Figure 30).

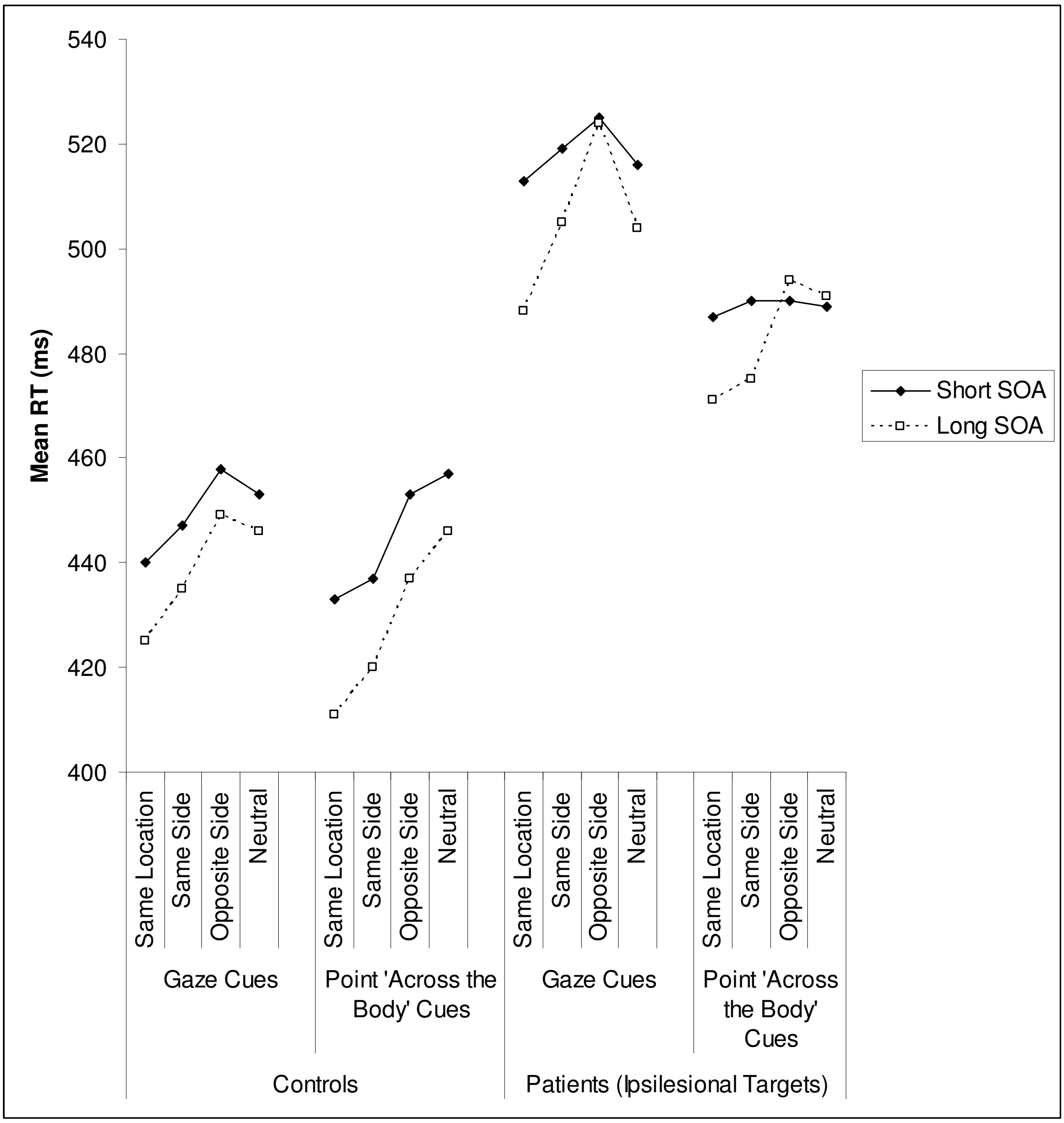

Figure 30. Illustration of Validity effects in the upright Gaze and upright Pointing 'Across the Body' cues between the age-matched controls (collapsed across side) and patients' ipsilesional target detection.

Controls vs. Patients – Contralesional Targets

The analysis revealed significant main effects of Group (*F* (1, 14) = 6.121, *p* = .027; Controls 440ms, Patients 543ms) and Cue Type (*F* (1, 14) = 6.296, *p* = .025; Gaze 503ms, Pointing Across

480ms). There were significant effects of Validity and SOA (both *p*s < .002), but these have been reported in detail in the previous sections so will not be repeated here. As for the analysis of patients' ipsilesional targets detection (see above) there was no significant Cue Type by Validity interaction (*p* > .405). Bonferroni-corrected comparisons showed a marginal location-specific cueing effect (Same Location 479ms, Same Side 490ms, *p* = .059), although there was a significant advantage for Same Side cues (490ms) over Neutral cues (502ms, *p* = .038) which suggests that the cueing effect was generalised to a shift in attention to the correct side (see Figure 31).

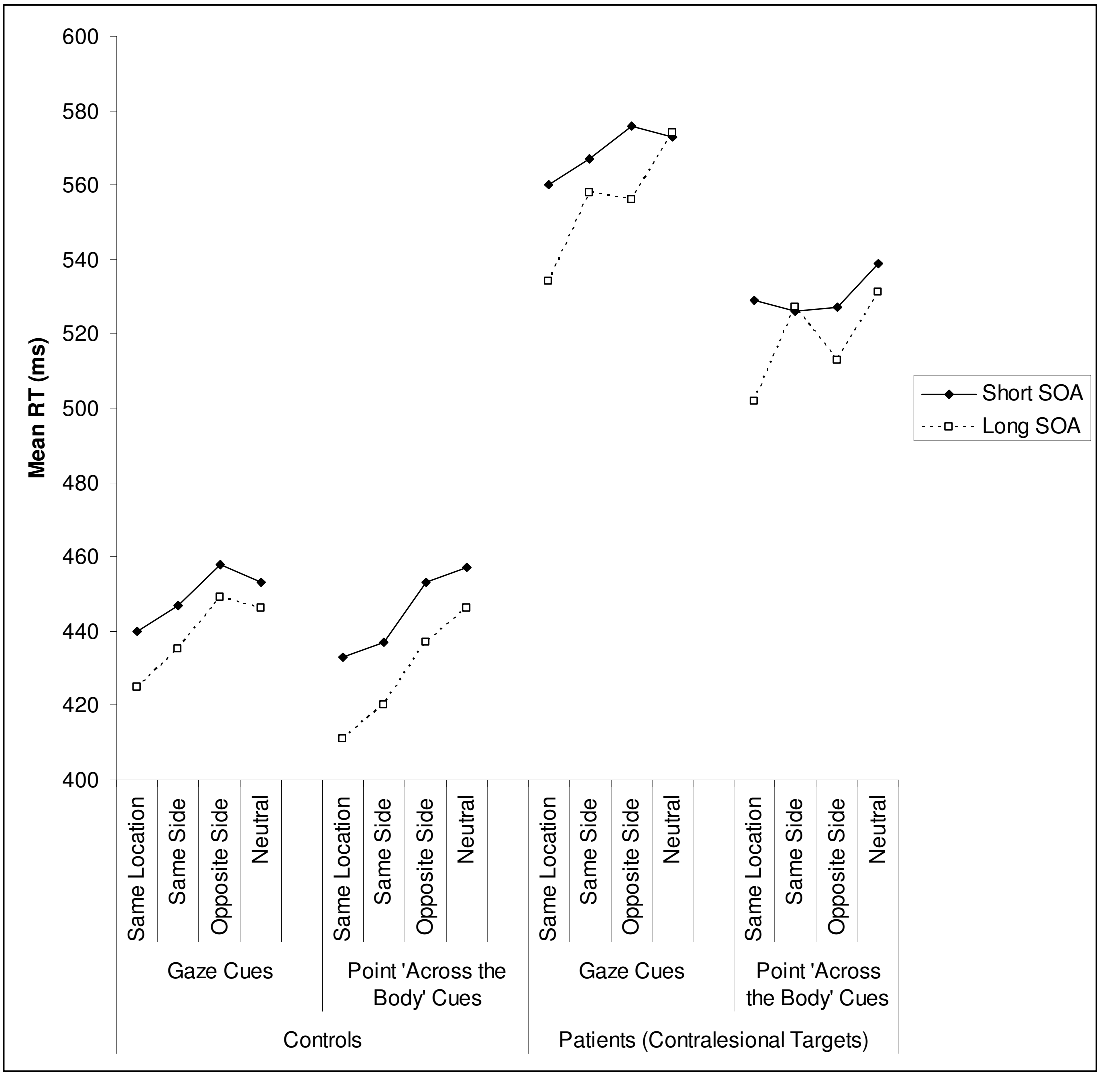

Figure 31. Illustration of Validity effects in the upright Gaze and upright Pointing 'Across the Body' cues between the age-matched controls (collapsed across side) and patients' contralesional target detection.

3.12 Main Discussion

The main purpose of the experiments was to look for evidence of location-specific cueing effects for each of the different cues presented. The results from the parietal-damaged patient group and the age-matched control group will be discussed separately, with comparisons being drawn between the two groups, and then between types of cue. The analyses of patient performance have shown that patients are generally slower to respond to targets appearing in their contralesional visual field than the age matched controls, as expected. However, the analyses did not show any interactions between cue validity and group, which shows that although patients attentional orienting was slower due to parietal-damage, they were still able to interpret and follow the central cues as accurately as controls, even when targets appeared on their ‘bad’ side.

The cross-experiment analysis between the gaze and subtle pointing cues showed no differences in validity effects of each cue, with location specific cueing effects for both controls and patients’ ipsilesional target detection. However when targets appear to the patients’ contralesional side there is an overall RT advantage for the subtle pointing cues over the gaze cues, with both cues inducing a general cueing effect to the cued side, but not specifically to the correct location. The cross-experiment analyses showed no differences in the validity effects associated with the pointing Hand cue and the subtle pointing cue, indicating that it makes no difference whether the hand is presented in the context of the rest of the body for the cueing effects to occur. This was true for both ipsilesional and contralesional targets detection for patients, and for the controls.

Importantly, there was no interaction between the cue type, cue validity and group factors, which shows that patients and controls produced similar validity effects across the different types of pointing cues (Hand cue vs. subtle pointing cue) and gaze cues (Gaze cue vs. subtle pointing cue). This supports the notion that pointing cues are social in nature, and thus are as potent as gaze cues in directing attention to specific locations in the environment. The cueing effect of the pointing gesture is not lost when the hand is presented in isolation, rather than as part of the body which suggests that the gesture is processed independently of the rest of the body (cf. Reed et al., 2003). This is not to say that the pointing cue is any less ‘social’ in nature than eye gaze cues, but that they are processed differently (not as a configuration) to allow for the extraction of and attention to relevant gestures. We have also shown that gaze cues are relatively insensitive to inversion in this type of experiment, possibly due to top-down control mechanisms precluding the influence of irrelevant facial features (e.g. nose and mouth areas).

Overall the findings imply that gaze is not unique in its ability to orient attention reflexively and accurately in normal observers, which supports previous experiments when gaze cueing is compared to that of arrows (e.g. Tipples, 2002). Further to this finding, our results show that this reflexive and accurate orienting response also occurs in response to human pointing cues, despite cue direction being non-predictive to target location and participants being told to ignore the cues. Vuilleumier (2002) suggested that reflexive location-specific orienting occurs due to the unique social relevance of gaze, and as such that this cueing effect is not apparent for symbolic arrows. However, we have shown that pointing hand cues have the same influence of attentional reorienting as eye gaze cues in normal observers and parietal damaged patients, and that the effect of hand gestures allows for more accurate reorienting than do symbolic arrow cues (see Chapter 2) in both groups. However, Vecera and Rizzo (2004) have argued that reflexive reorienting of attention can be achieved by gaze shifts and arrows alike, through over-learned associations between direction and interesting stimulus locations for each cue. Our findings thus could be explained in these terms, that is, via an over-learned association between the direction of someone else's pointing gesture, and an area of potential interest in the environment. This would call into question our conclusion that pointing gestures have a special social relevance per se, and put them in the same category as arrow cues, where orienting is modulated by over-learned associations. It is beyond the scope of this chapter to address this question here, but the relative 'social' nature of the gaze and pointing cues will be assessed in the following chapter with a patient who displays a theory of mind deficit. That is, since this patient cannot infer the mental states of others that are required for gaze following (Baron-Cohen, 1995) we can establish whether the pointing cue requires social meaning to be extracted, or if it is purely directional in nature.

CHAPTER 4:

THE EFFECT OF SOCIAL CUES ON THE REORIENTING OF VISUAL ATTENTION IN A PARIETAL-DAMAGED PATIENT WITH A THEORY OF MIND DEFICIT

PART I:

SCHEMATIC SOCIAL CUES

4.1 Introduction

Our ability to reason about the mental states of others, such as their beliefs, desires and own knowledge is collectively known as ‘theory of mind’. Theory of mind is considered to be the means by which we understand and predict the behaviour of other people, and hence engage in effective and appropriate social communication. Belief reasoning involves the knowledge that someone else can hold beliefs that are different to our own, and is usually assessed by stories in which the protagonist is unaware of a change to a situation. Baron-Cohen et al. (1985) suggest that autistic children fail to interpret mental states of others, and as such fail to display a normal theory of mind.

This finding has been replicated many times in the developmental literature over the years, but Apperly, Samson, Chiavarino and Humphreys (2004) noted that there are relatively few studies have investigated belief reasoning in adults and how this breaks down following brain damage. Furthermore, the link between ToM and EDD and SAM (Baron-Cohen, 1995) is less clear in the context of acquired ToM deficits as opposed to developmental disorders. That is, whereas Baron-Cohen (1995) suggests that EDD and SAM are developmental precursors to ToM, it is equally possible that an acquired ToM deficit may lead to impaired EDD and/or SAM, or vice versa. These alternative explanations will be returned to later in the Discussion section of this chapter, and in the General Discussion. Apperly et al. (2004) developed a belief reasoning task which does not place heavy demands on language or executive function, in order to investigate levels of belief reasoning in a group of neuropsychological patients. They found that patient RH had a pure belief reasoning deficit without a concurrent deficit in executive function. However, Njomboro et al. (2008) argued that such patients may still have a specific deficit in using subtle information about eye gaze to support theory of mind reasoning. Preliminary analyses of pilot data revealed that patient RH showed no significant effect of gaze validity in Experiment 1 ($p > .05$) and as such RH was treated as a single case study of a parietal-damaged patient who also presents with a theory of mind deficit. Like the patients presented in Chapters 2 and 3, RH presented with a unilateral parietal lesion following a stroke and displayed visual neglect and extinction. However unlike the patients presented in Chapter 2, RH also has an acquired ToM deficit (Apperly et al., 2004). Following on from Njomboro et al. (2008), and from the questions which emerged from the previous Chapter regarding the social significance of gaze and pointing cues, we were interested in whether RH would perform in the same way as the parietal patients in Chapter 2 and 3, or whether he is not able to use the social cues to guide attention. A group of age-matched controls (different to those presented elsewhere) were tested in the same experiments to provide a ‘normal’ measure of performance, to compare against patient RH and give an indication of his level of impairment. Specifically, this chapter addressed the following research questions:

1) Given a ToM deficit, can RH use information from schematic pointing cues to direct attention? How does this compare with his performance with a directional arrow? If orienting in response to pointing cues is reliant upon the social relevance of the cue (i.e. the inferred mental state of the 'pointer') then the results may be the same as for eye gaze, that is, with no reliable cueing effects. However, if pointing cues are symbolically directional in nature, then in a patient with a ToM deficit there should be no difference between the relative cueing effects of a) schematic pointing cues and arrow cues; and b) realistic pointing cues represented in the context of the body and in the hand alone.

2) Pilot studies showed that RH was not able to use low-level schematic gaze cues to reorient attention (e.g., the stimuli described in Experiment 1), but how does this compare to his performance with realistic gaze cues? We present data from both the schematic and realistic gaze cue experiments, to verify whether schematic faces are processed in the same way more visually complex realistic faces (Tipples, 2005).

4.2 Methods

4.2.1 Participants

RH was a left-handed male who suffered a stroke affecting the left hemisphere in 1996. Lesions were present in the left inferior parietal lobe, including the angular and supramarginal gyrus, and in the superior temporal gyrus (STG). He presented with right side extinction on presentation of double-simultaneous stimuli, mild right visual neglect and aphasia. RH was 73 years of age at time of testing, and was recruited through a voluntary participation panel of neurologically damaged patients at the University of Birmingham. Previous research has shown RH to have a theory of mind deficit as a result of his acquired brain injury (Apperly et al., 2004) but in addition RH was also assessed using the BCoS II: Social Predictions Test (Humphreys et al., in preparation). The Birmingham Cognitive Screen (BCoS) is a battery of tests designed to assess cognitive function following a stroke. The Social Predictions test relates to the participants' theory of mind abilities, and is consists of eight everyday scenarios, each illustrated by six pictorial sequences with written narration which the examiner reads to the participant. At the end of each scenario, the participant is asked a question about the main character in the story, and is given three possible answers to choose from. Two questions relate to the character's intention, two questions relate to the character's belief, two questions relate to the character's emotional state, and there are two control questions concerning logical reasoning about physical properties of objects. Patient RH scored 4 out of 8 correct on this test, failing both of the belief questions, one intention question and one emotion question. All other patients who took part in the experiments in Chapters 2 and 3 scored at ceiling on this test, as did the age-matched controls who took part in all experiments within this thesis. Please refer to Appendix II for a summary of patient RH's lesion details and clinical deficits.

Five neurologically intact male controls were also recruited through a volunteer panel at the University of Birmingham. The controls were age-matched to patient RH as closely as possible (mean age 73.8 years; SD 4.60; age range 69 – 81 yrs) and were all right handed due the lack of left handed male controls on the volunteer panel within the required age range.

4.2.2 Design

The design for all Experiments in this Chapter was the same as for Experiment 1. See section *2.2.2 Design* in Chapter 2 for details.

4.2.3 Procedure

The procedure was the same for all Experiments in this Chapter. Patient RH completed 4 runs of each of the experiments, in order to achieve greater statistical power with the case study of a single patient. During each experiment, RH was offered rest breaks after every 37 trials, totalling ten blocks per experiment, per run. However, the controls completed one run of each of the experiments, due to a larger sample size and controls generally producing more consistent data relative to neurologically damaged patients. Controls were offered a short rest break half way through each experiment, so completed the experiments in blocks of 185 trials.

In each experiment, all participants were instructed to keep their eyes fixated on the centre of the screen, and not to look towards to target locations or targets themselves when they appeared, but simply to press the spacebar whenever they detected a target in their peripheral vision. However when no target was present, the participants were instructed to refrain from making a response and wait for the next trial. The experimenter carefully watched each participant for the first ten trials, periodically monitored eye movements, to check that fixation was maintained at the centre of the screen. In addition, at each rest break a written instruction appeared on the computer screen to remind the participants to keep their eyes fixated at the centre of the screen at all times.

Experiment 7: Upright vs. Inverted Schematic Eye Gaze Cues

4.2.4 Materials

The materials for this experiment were the same as in Experiment 1. See section *2.2.4 Materials* in Chapter 2 for details.

4.3 Results

For the all Experiments there were 20 trials per condition. Within the control group, misses and anticipatory responses were removed from the data (0.09% and 0.27% of total data set, respectively). RTs outside of 2 SDs of the mean (3.64% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition in each experiment. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (4.37% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs for each experiment. The data from the upright and inverted gaze experiments were first compared between the control group and patient RH in separate analyses according to ipsilesional and contralesional targets for RH, and then the data from RH was analysed to determine whether there were differential effects of field of presentation.

The results were analysed in the same way for each Experiment in this Chapter. For the comparison of control and patient performance, the data were entered into a 2 (Group: Controls, RH) * 2 (Orientation: Upright cue, Inverted cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) mixed-design ANOVA[5].

4.3.1 Controls vs. RH – ipsilesional target detection

The analysis revealed a significant main effect of Group (*F* (1, 7) = 131.938, $p < .001$; Controls 380ms, RH 600ms). There was a significant main effect of Validity (*F* (3, 21) = 11.326, $p < .001$) which interacted with the Group factor (*F* (3, 21) = 3.707, $p = .028$). There was an interaction between SOA and Group (*F* (1, 7) = 15.099, $p = .006$), and between Orientation, Validity and Group (*F* (3, 21) = 3.147, $p = .047$; see Figure 32). Since Group interacted with all other factors, separate 2 (Orientation: Upright Gaze, Inverted Gaze) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) within-subjects ANOVAs were carried out for the control group and patient RH.

For patient RH, there were no significant effects of Orientation, Validity or SOA and no interactions (all *p*s > .103). However, for the control group there were significant main effects of Validity (*F* (3, 12) = 29.511, $p < .001$) and SOA (*F* (1, 4) = 25.286, $p = .007$; short 391ms, long 364ms). Bonferroni-corrected comparisons between the Validity conditions show that the control group show location-specific cueing effects, with Same Location (353ms) cues eliciting significantly faster RTs than Same Side (379ms, $p = .023$) cues, as well as Opposite Side (395ms, $p < .001$) and Neutral (391ms, $p = .005$). There was no significant difference between RTs in the latter three conditions (all *p*s > .101).

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[5] Since the factor of 'Target Side' was not significant for the control group in any of the experiments in this Chapter (all *p*s > .945), the data from RH was divided according to ipsilesional and contralesional target trials and analysed alongside control data in separate ANOVAs.

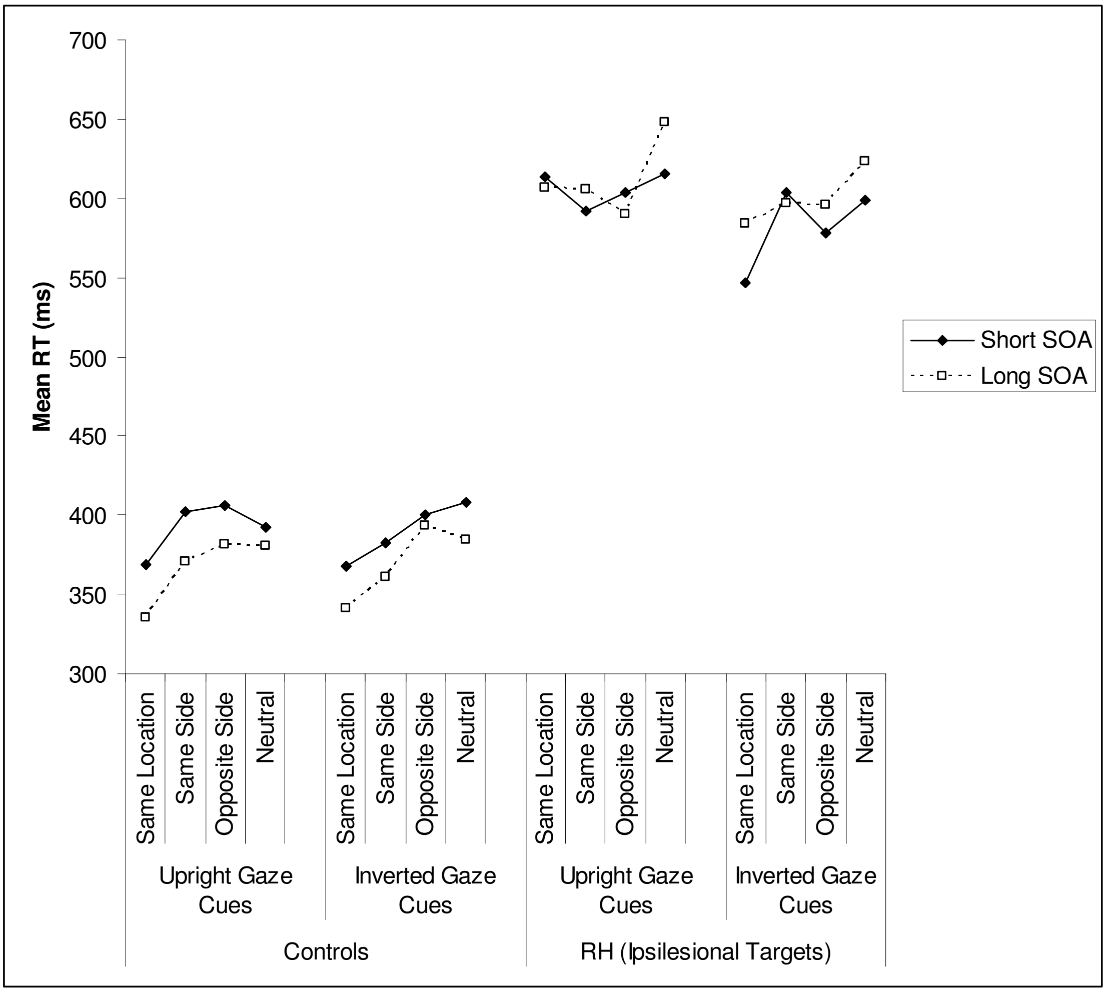

Figure 32. Illustration of Validity effects at both SOAs for the Control group and patient RH (for ipsilesional target detection) in the Upright and Inverted schematic gaze cue experiments.

4.3.2 Controls vs. RH – contralesional target detection

The analysis revealed a significant main effect of Group (*F* (1, 7) = 95.793, *p* < .001; Controls 380ms, RH 592ms). There was no significant main effect of Validity (*p* > .05), but there was a significant interaction between Validity and Group (*F* (3, 21) = 4.918, *p* = .039). There was also an interaction between SOA and Group (*F* (1, 7) = 29.372, *p* = .001; see Figure 33). Bonferroni-corrected comparisons between the Groups and SOAs showed that the control group showed the expected effect of faster RTs following the long (369ms) than the short (391ms, *p* = .016) SOA. However, patient RH showed the opposite pattern, with faster RTs following the short (574ms) than the long (609ms) SOA.

Bonferroni-corrected comparisons between the Validity conditions for the control group have been reported in the section above (*Controls vs. RH – ipsilesional target detection*) and so will not be repeated here. For patient RH there were no significant differences between RTs in any of the Validity conditions (Same Location 593ms, Same Side 598ms, Opposite Side 602ms, Neutral 575ms; all *p*s > .139).

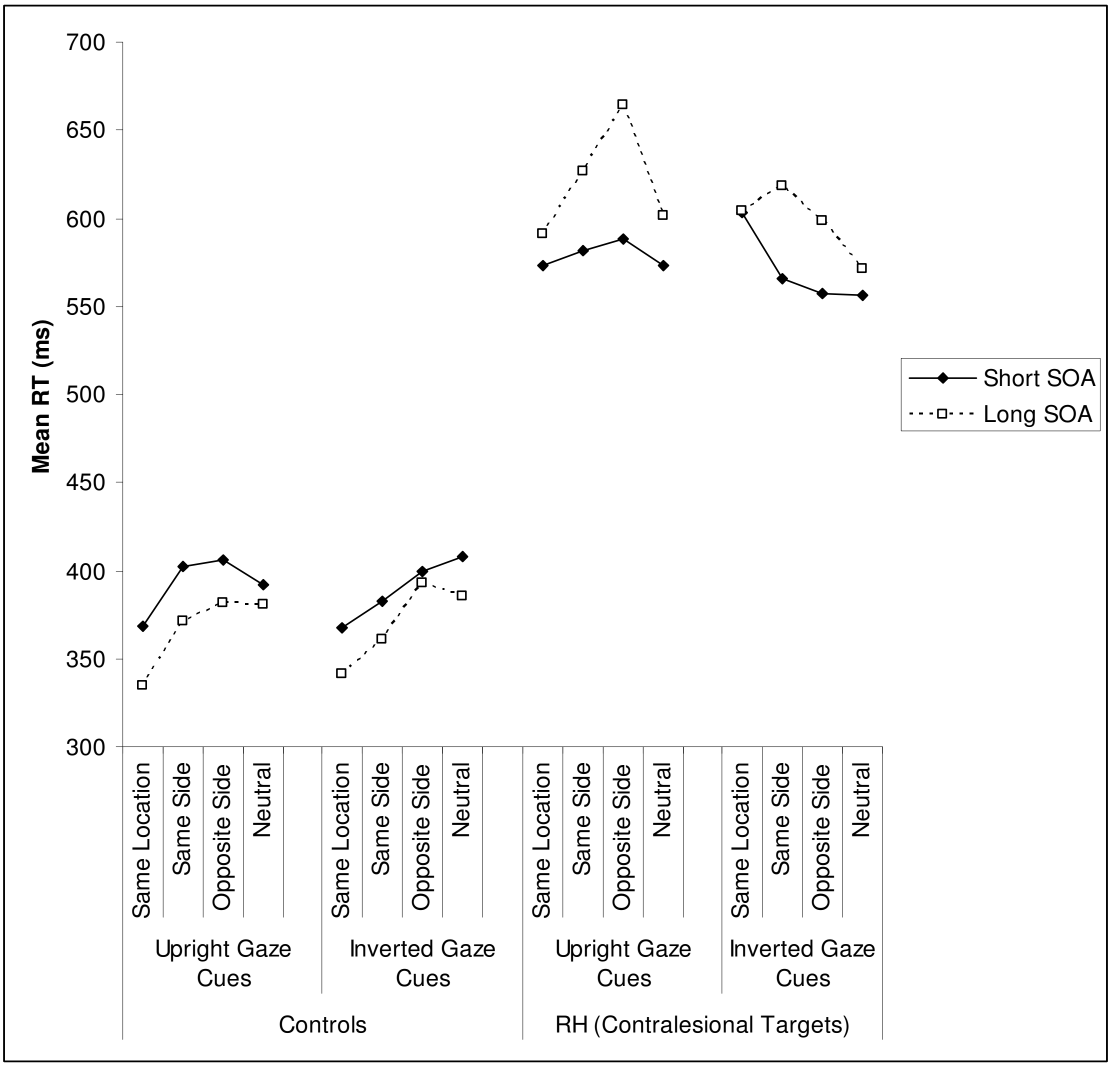

Figure 33. Illustration of Validity effects at both SOAs for the Control group and patient RH (for contralesional target detection) in the Upright and Inverted schematic gaze cue experiments.

4.3.3 Patient RH

The data for Patient RH for each of the four experimental sessions was entered into a 2 (Orientation: Upright Gaze, Inverted Gaze) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Ipsilesional, Contralesional) * 2 (SOA: Short, Long) within-subjects ANOVA, to allow for a comparison of his performance in the ipsilesional and contralesional visual fields. The analysis showed no main effects, but significant interactions between Validity and Side (*F* (3, 9) = 4.650, *p* = .032) and between Side and SOA (*F* (1, 3) = 24.373, *p* = .016). Bonferroni-corrected comparisons showed no significant differences in RTs between Validity conditions for either target Side (all *p*s > .150) as reported in the *Controls vs. RH* analyses above (see sections *4.3.1* and *4.3.2*). There was only a significant difference in RTs between ipsilesional and contralesional target detection in the Neutral validity condition (MD 46ms, *p* = .009), although this was not in the expected direction, as contralesional targets were detected faster than ipsilesional targets. This suggests that patient RH adopts a strategy-driven approach to gaze following. That is, when he is cued by a gaze shift (regardless of validity), RH is focussed on the cue and so does not orient quickly to either side. However, when the gaze cue remains still (i.e. 'neutral' straight ahead gaze) he compensates for the attentional deficit by first orienting to his neglected side.

Bonferroni-corrected comparisons between the Side and SOA factors showed that there was only a significant effect of SOA for contralesional target detection (MD 35ms, *p* = .046). However, this was again in the unexpected direction, where targets were detected more rapidly following a short than a long SOA.

4.4 Discussion

The control group exhibited location-specific cueing effects for both upright and inverted gaze cues, across SOAs, which is indicative of exogenous orienting. This finding is in support of Vuilleumier (2002; location-specific cueing) and Driver et al. (1999; automatic, reflexive orienting in response to gaze), but contradicts Langton and Bruce (1999) who found that inversion of the central face cue disrupts gaze cueing effects. However, the effect is consistent with that of the previous group of controls in Chapter 2, which supports the cueing effect of schematic faces and our previous claim that inversion effects only occur for whole face/head turns (cf. Langton and Bruce, 1999). Conversely, and as expected from our pilot data, Patient RH showed no significant validity effects in response to the upright or inverted cues. His data provide an absolute measure of his ability to orient his attention in response to simple gaze cues, this can be compared with his performance with other cues (i.e. pointing and arrows). We can now say with confidence that patient RH shows no reliable cueing effect in response to simple schematic eye gaze shifts.

When gaze remained straight ahead in the neutral conditions, RH showed a reversed effect of side, where contralesional targets were detected significantly faster than ipsilesional targets. This suggests a compensatory strategy where RH has learned to orient to his neglected side first. Furthermore, for contralesional targets RH showed a reversed SOA effect where RTs were slower following a long than a short SOA, which is the opposite effect to that found in covert cueing paradigms more generally (Posner, 1980; Posner et al., 1984). However, this reversed SOA effect was also present in a group of autistic children in a gaze cueing study (Swettenham et al., 2003). The authors proposed that this effect is possibly due to autistic children being slower to prepare and initiate responses more generally, independently of social gaze processing. It seems plausible to extend this explanation to our ToM patient RH, especially in light of the observation that his reaction times were indeed significantly slower than those of controls, both for contralesional and ipsilesional target detection.

Experiment 8: Upright vs. Inverted Schematic Pointing Cues

4.5.1 Materials

The materials for this experiment were the same as in Experiment 2. See section *2.5.1 Materials* in Chapter 2 for details.

4.6 Results

Within the control group, misses and anticipatory responses (0.10% and 0.31% of total data set, respectively) were removed from the data. RTs outside of 2 SDs of the mean (4.01% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition in each experiment. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (4.87% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs for each experiment.

4.6.1 Controls vs. RH – ipsilesional target detection

The analysis revealed a significant main effect of Group (F (1, 7) = 100.975, p < .001; Controls 395ms, RH 652ms), which interacted separately with Orientation and Validity: Orientation by Group (F (1, 7) = 7.482, p = .029), Validity by Group (F (3, 21) = 4.594, p = .013). There was also a significant interaction between Orientation and SOA (F (1, 7) = 6.533, p = .038; see Figure 34). For the Orientation by Group interaction, Bonferroni-corrected comparisons showed that only patient RH showed an effect of Orientation, with ipsilesional target detection being more rapid following upright than inverted pointing cues (Upright 622ms, Inverted 682ms, p = .024; Controls MD 16ms, p > .406). For the Orientation by SOA interaction, Bonferroni-corrected comparisons showed that there was only an effect of SOA following inverted pointing cues (short 545ms, long 524ms, p = .001). The Validity by Group interaction was also broken down with Bonferroni-corrected comparisons. For the control group there were location-specific cueing effects, with Same Location cues (372ms) eliciting significantly faster RTs than Same Side cues (392ms, p = .011), Opposite Side cues (415ms, p = .005) and Neutral cues (403ms, p = .021), with no significant difference between the RTs in the latter three conditions (all ps > .050). However, the difference between Same Side (392ms) and Opposite Side cues (415ms) almost reached statistically significance (p = .051). For patient RH, Bonferroni-corrected comparisons also showed location-specific cueing effects with significantly faster RTs following Same Location cues (607ms) than Same Side cues (661ms, p < .001), Opposite Side cues (674ms, p = .001) and Neutral cues (667ms, p = .001). However for RH, none of the differences between the RTs in the latter three conditions approached significance (all ps > .752).

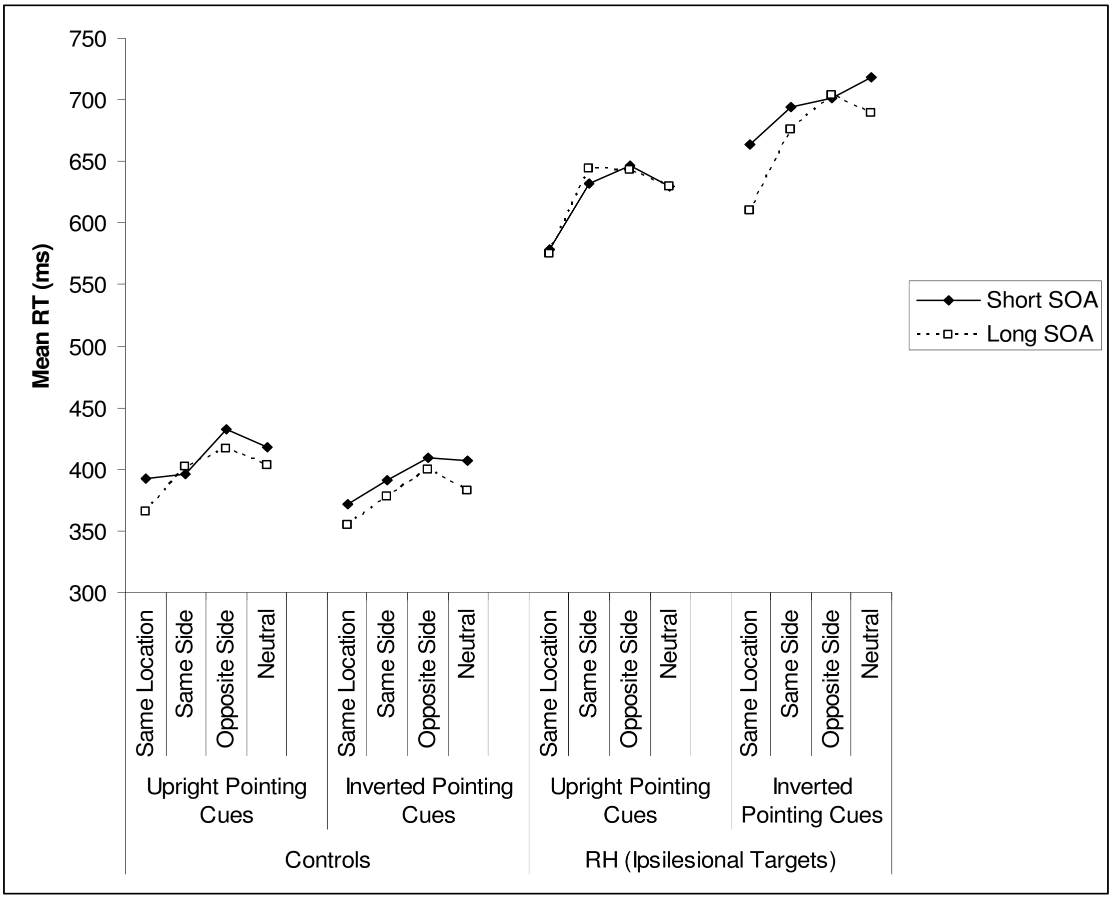

Figure 34. Illustration of Validity effects at both SOAs for the Control group and patient RH (for ipsilesional target detection) in the Upright and Inverted pointing cue experiments.

4.6.2 Controls vs. RH – contralesional target detection

The analysis revealed a significant main effect of Group (*F* (1, 7) = 113.608, *p* < .001; Controls 395ms, RH 646ms), which interacted with all other factors: Orientation by Group (*F* (1, 7) = 6.205, *p* = .042), Validity by Group (*F* (3, 21) = 12.045, *p* < .001), SOA by Group (*F* (1, 7) = 13.499, *p* = .008). These were qualified by a significant four-way interaction between Group, Orientation, Validity and SOA (*F* (3, 21) = 2.251, *p* = .007; see Figure 35), which was decomposed by a separate 2 (Orientation: Upright Point, Inverted Point) * 4 (Validity: Same

Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) within-subjects ANOVA for each group (controls, RH).

For the control group, the analysis revealed a significant main effect of Validity (*F* (3, 12) = 14.459, *p* < .001), where Bonferroni-corrected comparisons showed location-specific cueing effects, as discussed in the previous section (see *Controls vs. RH – contralesional target detection*). However, the effects of SOA and Orientation did not approach significance (both *p*s > .162).

For patient RH, the analysis revealed significant main effects of Validity (*F* (3, 9) = 25.876, *p* < .001) and SOA (*F* (1, 3) = 15.918, *p* = .028; short 633ms, long 659ms), and a significant interaction between Orientation and Validity (*F* (3, 9) = 12.505, *p* = .001). Bonferroni-corrected comparisons between Validity conditions in the Upright Pointing cue experiment showed that there was no location-specific cueing effect (Same Location 587ms, Same Side 615ms, *p* = .541), and that Opposite Side (726ms) cues elicited significantly longer RTs than all other conditions (all *p*s < .015). The Neutral condition elicited the fastest RTs (575ms), with the difference reaching significance in comparison to Same Side (*p* = .008) and Opposite Side (*p* = .014) conditions, but not in relation to Same Location cues (*p* > .999). Overall, the pattern of Upright Pointing Validity effects for contralesional targets is consistent with a disengage deficit in patient RH. For the Inverted Pointing cues, Bonferroni-corrected comparisons revealed no significant difference between RTs in any of the Validity conditions (Same Location 629ms, Same Side 671ms, Opposite Side 698ms, Neutral 666ms; all *p*s > .295).

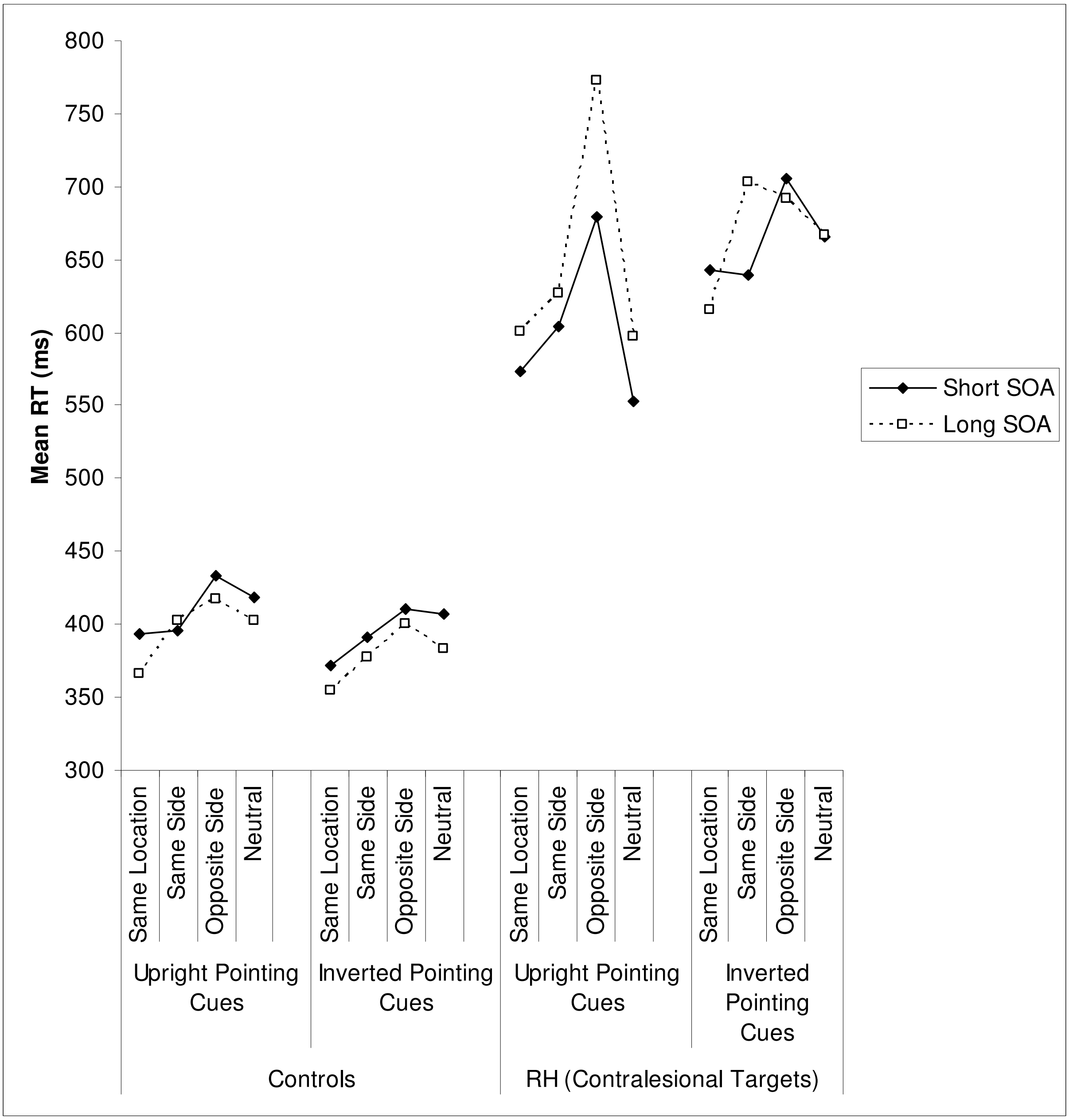

Figure 35. Illustration of Validity effects at both SOAs for the Control group and patient RH (for contralesional target detection) in the Upright and Inverted pointing cue experiments.

4.6.3 Patient RH

The data for Patient RH for each of the four experimental sessions was entered into a 2 (Orientation: Upright Point, Inverted Point) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Ipsilesional, Contralesional) * 2 (SOA: Short, Long) within-subjects ANOVA, to allow for a more in-depth analysis of his performance in the contralesional and ipsilesional visual fields. The analysis showed a significant main effect of Validity (F (3, 9) = 41.644, $p < .001$) which interacted with Orientation (F (3, 9) = 6.164, $p = .015$) and with Side (F (3, 9) = 12.935, $p = .001$), which were qualified by a significant three-way Orientation by Validity by Side interaction (F (3, 9) = 7.739, $p = .007$). This three-way interaction was decomposed by separate 2 (Orientation: Upright Point, Inverted Point) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) ANOVAs for each Side (ipsilesional, contralesional). These analyses showed the same pattern of Validity effects as seen in the analyses with the controls. For ipsilesional target detection RH showed location-specific cueing effects across cue orientations. For contralesional target detection however, RH showed a pattern of RTs consistent with a disengage deficit in response to Upright Pointing cues, but there was no significant Validity effect following Inverted Pointing cues.

The analysis also revealed a significant main effect of SOA (F (1, 3) = 10.584, $p = .047$), which interacted with Orientation (F (1, 3) = 192.312, $p = .001$) and with Side (F (1, 3) = 14.832, $p = .031$). Bonferroni-corrected comparisons between the Orientation and SOA factors showed that for the Upright Pointing cues, short SOAs elicited significantly faster RTs than long SOAs (MD 24ms, $p = .003$), which is the opposite pattern to that expected. However, when the Pointing cues were Inverted, the effect of SOA was as expected with significantly faster RTs following a long SOA than a short SOA (MD 9ms, $p = .037$). Bonferroni-corrected comparisons between the Side and SOA factors showed that following a short SOA, contralesional targets were detected significantly faster than ipsilesional targets (MD 25ms, p = .012), which is counter-intuitive and suggestive of a strategy-driven approach to attentional reorienting. This post-hoc analysis also revealed a counter-intuitive effect of SOA for contralesional target detection, where short SOAs elicited significantly faster RTs than long SOAs (MD 27ms, p = .028).

4.7 Discussion

The upright and inverted pointing cues elicited location specific cueing effects in the control group across the SOAs, which is indicative of exogenous orienting, and supports the findings reported in a different control group Chapter 2. A location-specific cueing effect was also apparent for patient RH, although only for ipsilesional target detection. When targets appeared on the contralesional side, RH showed a disengage deficit in response to upright cues, and no significant effects of validity when the pointing cues were inverted. The failure to find a validity effect with inverted cues suggests that the pointing cues were processed independently of the body. This finding is in support of Reed et al. (2003) who showed that bodies were subject to similar configural processing and inversion effects as eye gaze cues. Therefore, when configural processing is disrupted by inversion, RH shows a decreased ability to follow the pointing cues. Nevertheless, the most important finding with respect to our original research question was RH was able to orient his attention to specific locations in response to pointing cues, only when presented in canonical orientations. The suggestion here is that RH can infer directional meaning from another person's gestures, and use these gestures to direct his attention to specific locations, in ipsilesional space at least. There are differences therefore between gaze and pointing cues in

RH, which suggests either that a) RH's ToM deficit renders him unable to follow gaze cues but orienting in response to other social cues such as pointing is intact, or b) pointing is not a 'social' cue per se, and RH was following directional meaning without encoding the gesture as being portrayed by another person. Both of these possibilities have implications for theories of joint attention in ToM, but cannot be resolved until we establish RH's ability to orient attention in response to purely directional cues, i.e. symbolic arrows.

Experiment 9: Symbolic Arrow Cue

4.8 Methods

4.8.1 Materials

The materials for this experiment were the same as in Experiment 3. See section *2.8.1 Materials* in Chapter 2 for details.

4.9 Results

Within the control group, misses and anticipatory responses (0.07% and 0.12% of total data set, respectively) were removed from the data. RTs outside of 2 SDs of the mean (5.22% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (5.47% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs of the experiment. The data were entered into a 2 (Group: Controls, RH) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) mixed-design ANOVA.

4.9.1 Controls vs. RH – ipsilesional target detection

The analysis revealed significant main effects of Group (*F* (1, 7) = 56.435, *p* < .001; Controls 385ms, RH 617ms) and Validity (*F* (3, 21) = 25.342, *p* < .001), which were qualified by a significant interaction (*F* (3, 21) = 5.449, *p* = .006). There was also a significant interaction between Validity and SOA (*F* (3, 21) = 3.146, *p* = .047; see Figure 36). In order to tease apart these two two-way interactions, separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) within-subjects ANOVAs were performed for each Group (Controls, RH).

For the control group, the analysis revealed significant main effects of Validity (*F* (3, 12) = 12.554, *p* = .001) and SOA (*F* (1, 4) = 9.021, *p* = .040; short 394ms, long 377ms) which were qualified by a significant interaction (*F* (3, 12) = 7.205, *p* = .005). Bonferroni-corrected comparisons between the Validity conditions following the *short* SOA showed no significant differences in RTs between any conditions (all *p*s > .283). However, following the *long* SOA, Bonferroni-corrected comparisons showed a location-specific cueing effect (Same Location 342ms, Same Side 371ms, *p* = .048). In addition, the Same Side cues elicited significantly faster RTs than Neutral cues (403ms, *p* = .038), which suggests that the Validity effect may be driven by a general shift of attention to the correct side, rather than purely location-specific. Nevertheless, since this effect is only apparent after the long SOA, we must conclude that the arrow cue induced endogenous orienting mechanisms in the control group.

For patient RH, the analysis revealed significant main effects of Validity (*F* (3, 9) = 13.473, *p* = .001) and SOA (*F* (1, 3) = 18.386, *p* = .023; short 632ms, long 602ms), but no significant interaction (*p* > .243). However, Bonferroni-corrected comparisons between Validity conditions only showed a trend for location-specific cueing effects, with the difference in RTs between Same Location (556ms) and Same Side (632ms) cues not reaching statistical significance (*p* = .068). Furthermore, none of the comparisons between conditions approached significance (all other *p*s > .074), which suggests that for patient RH the arrow was an ineffective cue to ipsilesional target location across both SOAs.

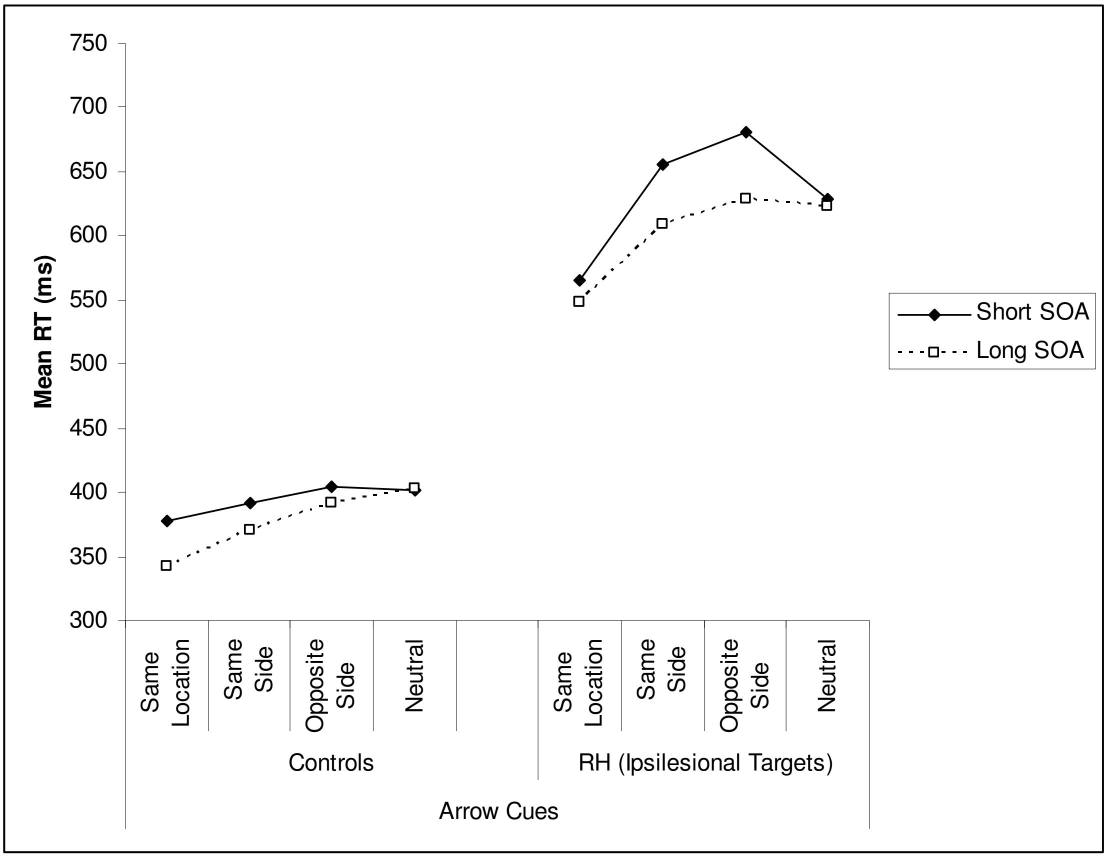

Figure 36. Illustration of Validity effects at both SOAs for the Control group and patient RH (for ipsilesional target detection) in arrow cue experiment.

4.9.2 Controls vs. RH – contralesional target detection

The analysis revealed significant main effects of Group (*F* (1, 7) = 39.006, *p* < .001; Controls 385ms, RH 602ms), Validity (*F* (3, 21) = 4.651, *p* = .012) and SOA (*F* (1, 7) = 28.966, *p* = .001), which were qualified by a significant three-way interaction (*F* (3, 21) = 3.120, *p* = .048; see Figure 37). This interaction was decomposed by separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) within-subjects ANOVAs for each Group (Controls, RH). For the control group, the effects of Validity and SOA have been discussed in the section above and so will not be repeated here. For patient RH, the analysis showed a significant main effect of SOA (*F* (1, 3) = 50.310, *p* = .006; short 563ms, long 642ms), which was again not in the expected direction since RTs were faster following a short SOA than following a long SOA. For contralesional target detection, RH showed no significant effect of Validity (*p* = .115) and no interaction between Validity and SOA (*p* = .261).

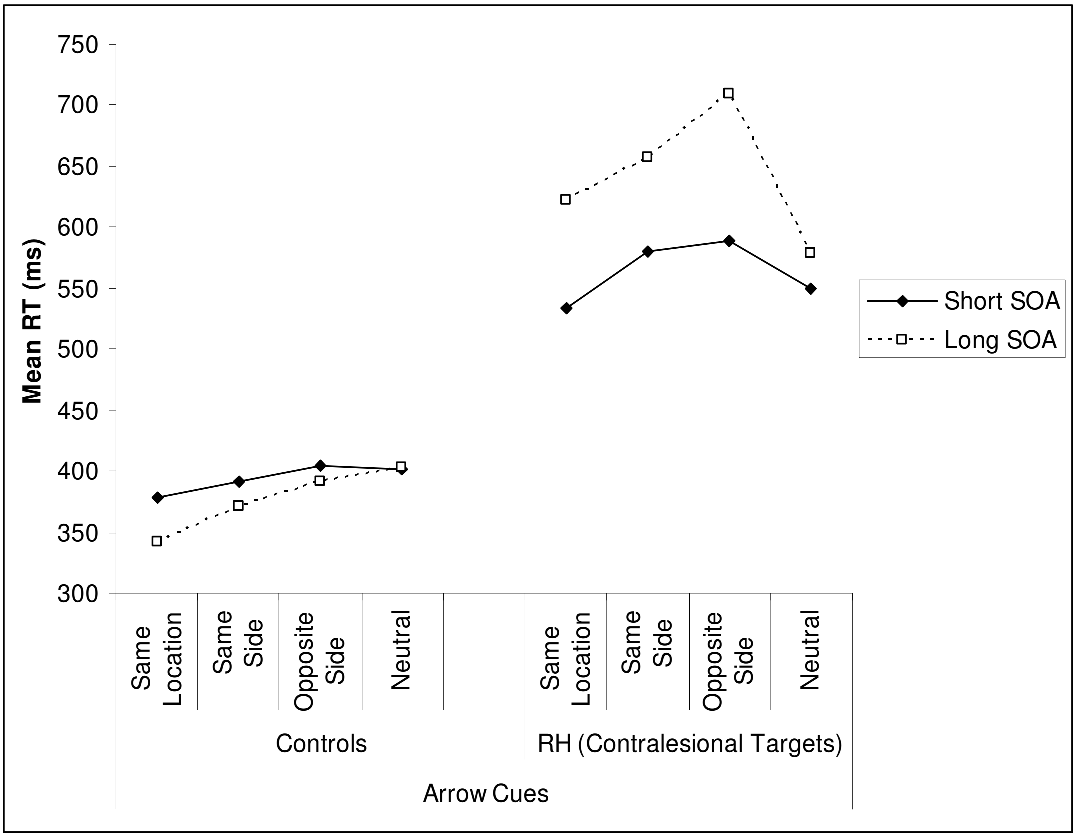

Figure 37. Illustration of Validity effects at both SOAs for the Control group and patient RH (for contralesional target detection) in arrow cue experiment.

4.9.3 Patient RH

The data for Patient RH for each of the four experimental sessions was entered into a 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Ipsilesional, Contralesional) * 2 (SOA: Short, Long) within-subjects ANOVA. The analysis showed significant main effects of Validity (*F* (3, 9) = 9.474, *p* = .004) and SOA (*F* (1, 3) = 12.620, *p* = .038), and a significant interaction between Side and SOA (*F* (3, 9) = 13.875, *p* = .003). Note that the analyses in the previous sections in this chapter revealed a normal effect of SOA for ipsilesional target detection, but a reversed effect of SOA for contralesional target detection. Bonferroni-corrected comparisons between the target Sides at each SOA show that following the short SOA, contralesional targets are actually detected significantly faster than ipsilesional targets (MD 69ms, *p* = .011). However, the expected effect of Side (i.e. faster RTs for ipsilesional than contralesional targets) was apparent following the long SOA, although the effect did not reach statistical significance (MD 40ms, *p* = .068). This is suggestive of a compensatory strategy-driven approach to target detection, where RH orients to his neglected side first, regardless of cue validity, which explains why contralesional target detection following a short SOA is so much faster than the ipsilesional and long SOA conditions. Bonferroni-corrected comparisons between the Validity conditions showed no evidence of location-specific cueing, where the only significant difference in RTs was between the Same Location (567ms) and Opposite Side (652ms, *p* = .020) conditions (all other *p*s > .146).

4.10 Discussion

The analyses showed that within the control group, there was evidence of location-specific cueing in response to the arrow cue, but only following the long SOA. Following the short SOA there was no significant effect of validity, which suggests that the arrow cue evokes endogenous orienting, which is in support of Vuilleumier's (2002) findings with neglect patients. However, our finding contradicts Tipples (2002) and Ristic et al. (2002) who found that arrow cues can induce exogenous orienting, and so we cannot draw strong conclusions regarding the relative exogenous/endogenous nature of arrow cueing since we failed to replicate the basic findings of

Tipples (2002) and Ristic et al. (2002). Furthermore, this effect is at odds with our previous controls group in Chapter 2, who showed cueing effects following the short and long SOAs. This apparent contradiction of findings can be explained by difference in sample size of the two experiments. The current analysis was based on data combined from one patient and five controls, whereas the effect in Chapter 2 was based on four patients and seven controls, perhaps rendering the latter analysis more powerful to detect an effect[6]. Nevertheless, what we are most interested in here is the performance of RH. Patient RH showed no location-specific cueing effect to either side in response to the symbolic arrow cue, but there was a general advantage for valid over invalid cues which was present at both SOAs and hence indicated reflexive orienting. This contrasts to RH's ability to orient to specific locations in response to a simple pointing gesture (Experiment 8), and supports the notion that the pointing gesture affords a more socially meaningful cue than does a symbolic arrow. The data suggest that RH can use socially meaningful information other than eye gaze to direct his attention, and thus that ToM deficits are modulated specifically by gaze following (cf. Baron-Cohen, 1995) rather than social orienting.

4.11 Cross Experiment Analyses

As in Chapter 2, we wanted to investigate differences in the magnitude of validity effects between the cues. To explore the potential differences in the validity effects associated with pointing gestures and arrow cues, these were also compared directly in a further analysis. However, since patient RH did not show any gaze validity effect, the comparison between gaze

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[6] However, it is important to note here that neither experiment has adequate power to detect an effect, given the typical cue validity effect size. However, please see discussion of the limitations of the experimental design and statistical analyses more generally, which are outlined at the end of this Chapter.

and pointing cues that was carried out in Chapter 2 was not carried out here. RH's performance with pointing cues has been discussed in detail in the relevant section, and so performing the gaze versus pointing analysis here would be unnecessary repetition. Data are presented first from control group compared to patient RH's ipsilesional target detection, followed by the control group compared to patient RH's contralesional target detection.

Pointing vs. Arrow Cues

The following analysis was carried out to compare the relative validity effects of the pointing gesture and the schematic gaze cue, between the age-matched controls and the parietal-damaged patients. Data were entered into a 2 (Group: Controls, RH) * 2 (Cue type: Pointing, Arrow) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA, separately for patients ipsilesional and contralesional target trials.

Controls vs. Patients – Ipsilesional Targets

The analysis showed significant main effects of Group (*F* (1, 7) = 65.426, *p* < .001; Controls 394ms, RH 620ms) and Validity (*F* (3, 21) = 42.045, *p* < .001) which were qualified by a significant interaction (*F* (3, 21) = 6.406, *p* = .003). There was also a significant interaction between Cue Type, Validity and SOA (*F* (3, 21) = 5.086, *p* = .008), which was decomposed by separate 2 (Cue type: Point, Arrow) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) ANOVAs per SOA, collapsed across groups (see Figure 38). Following the *short* SOA there was a significant main effect of Validity (*F* (3, 24) = 10.654, *p* < .001), where the only significant differences in RTs were between Same Location (468ms) and Opposite Side (527ms,

p = .006), and Same Side (505ms) and Opposite Side (527ms, p = .029). Following the *long* SOA there were significant main effects of Cue Type (F (1, 8) = 9.809, p = .014; Point 497ms, Arrow 477ms) and Validity (F (3, 24) = 41.717, p < .001) but no interactions. Bonferroni-corrected comparisons between Validity conditions showed location-specific cueing effects, with RTs in the Same Location (446ms) condition being significantly faster than RTs in all other conditions (Same Side 493ms, Opposite Side 507ms, Neutral 502; all ps < .001), but no significant differences between the latter three conditions (all ps > .290).

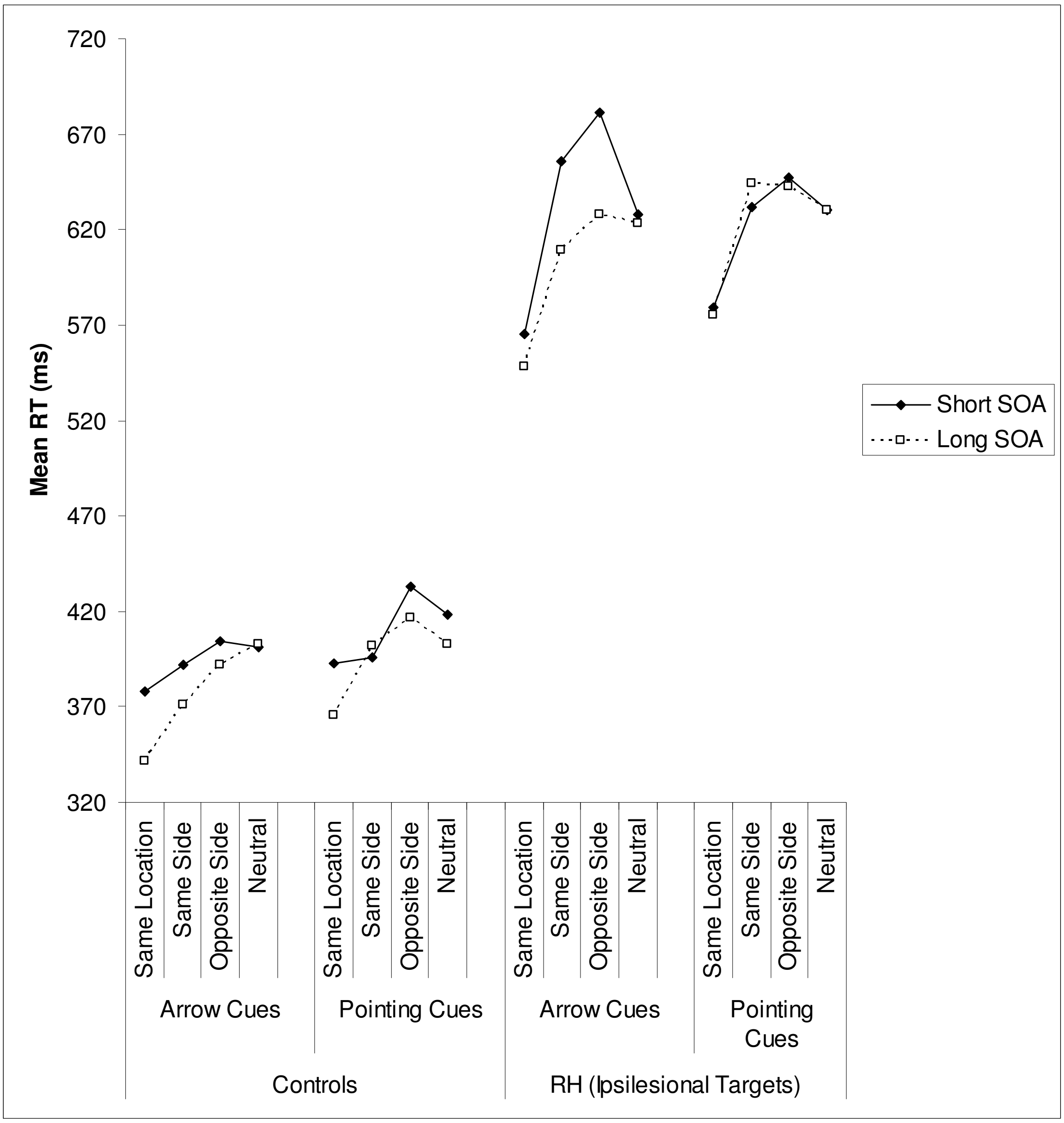

Figure 38. Illustration of Validity effects across SOAs for the Control group and patient RH (ipsilesional target detection) between the Arrow and Pointing cue experiments.

Controls vs. Patients – Contralesional Targets

The analysis showed significant main effects of Group (*F* (1, 7) = 60.448, *p* < .001; Controls 394ms, RH 614ms) and Validity (*F* (3, 21) = 29.021, *p* < .001) which were qualified by a significant interaction (*F* (3, 21) = 14.893, *p* < .001). There were also significant interactions between SOA and Group (*F* (1, 7) = 66.120, *p* < .001) and between Validity, SOA and Group (*F* (3, 21) = 4.353, *p* = .016). This three-way interaction was decomposed by separate 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) within-subjects ANOVAs for each group (see Figure 39). For the control group the analysis showed a significant main effect of Validity (*F* (3, 12) = 11.720, *p* = .001) which interacted with SOA (*F* (3, 12) = 3.927, *p* = .036). Following the short SOA, Bonferroni-corrected comparisons showed no significant difference between RTs in any of the Validity conditions (all *p*s > .099), although location-specific cueing effects were present across the cue types following the long SOA, with RTs in the Same Location (354ms) condition being significantly faster than RTs in Same Side (387ms, *p* = .005) condition, and no significant difference between RTs in Same Side and Neutral (403ms, *p* = .098). For the patient RH, the analysis showed significant main effects of Validity (*F* (3, 9) = 20.598, *p* < .001) and SOA (*F* (1, 3) = 109.537, *p* = .002; short 583ms, long 646ms). Bonferroni-corrected comparisons between the Validity conditions showed that Opposite Side (688ms) cues were detected significantly more slowly than Same Location (582ms, *p* = .039) and than Neutral (570ms, *p* = .006) cues. There were no other significant differences in RTs between the Validity conditions (all *p*s > .100), showing that there was no location-specific cueing effect for RH's contralesional target detection across the pointing and arrow cues, and that the effect of Validity was probably bolstered by the disengage deficit associated with the pointing cue.

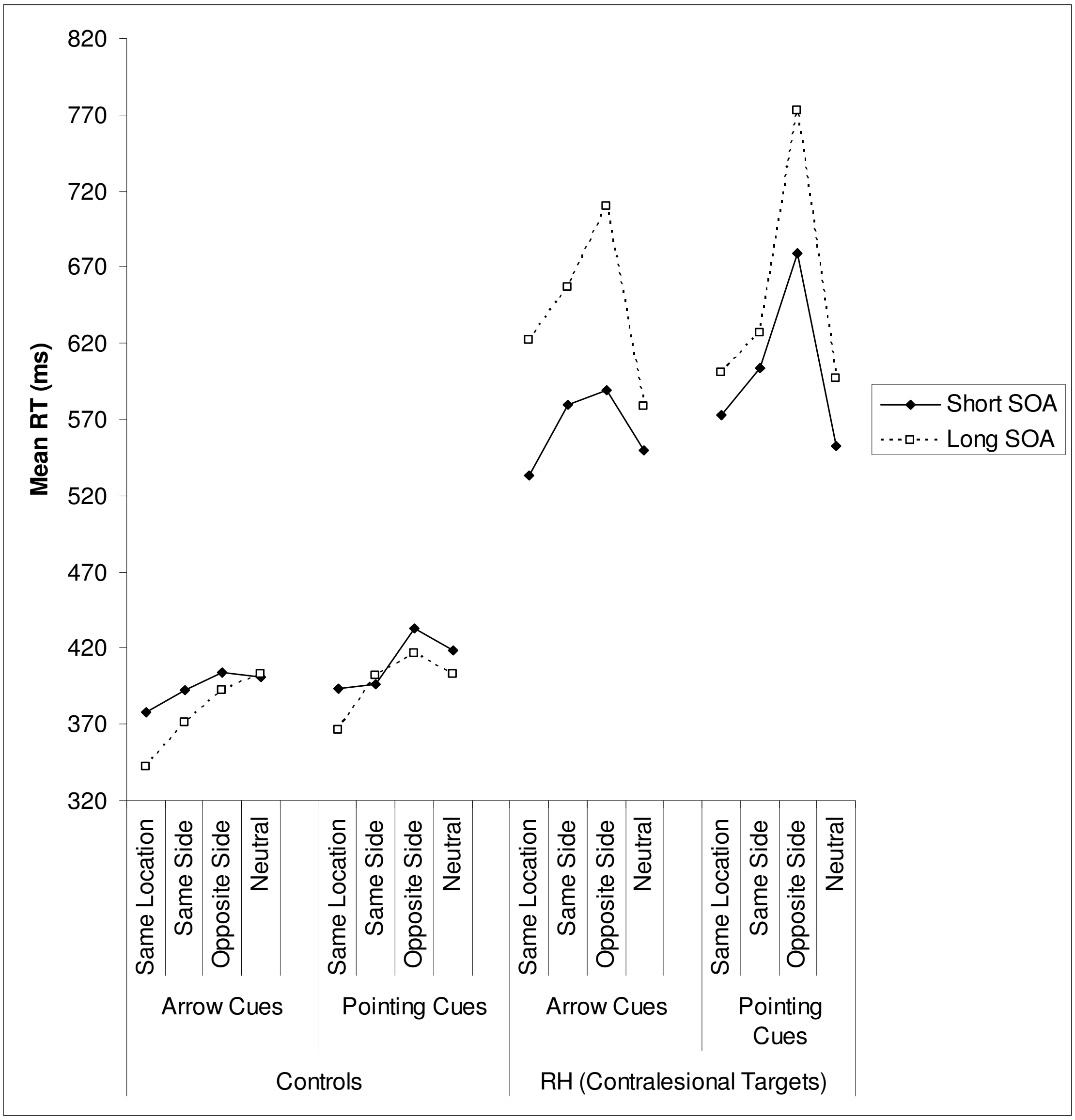

Figure 39. Illustration of Validity effects across SOAs for the Control group and patient RH (contralesional target detection) between the Arrow and Pointing cue experiments.

4.12 Main Discussion

Controls showed location-specific cueing effects with both gaze and pointing cues, across orientations and SOAs, which is indicative of all cues being processed exogenously. However, although the arrow cue did offer location-specific cueing benefits, this was only following the long SOA, which is consistent with a more strategy-driven endogenous processing style. For patient RH, there were no validity effects associated with the upright or inverted gaze cues, following either of the SOAs. This is consistent with his ToM deficit shown in other tasks (i.e. belief reasoning, Apperly et al., 2004) and also supports the findings of Teufel et al. (2010) who showed that gaze following can be modulated in normal observers by manipulation of mental-state attribution to the gazer (see Literature Review for a more detailed discussion of how this was achieved).

When pointing cues were presented in the upright orientation RH showed location-specific cueing effects for targets appearing on his ipsilesional side, but a disengage deficit in response to invalid cueing when targets appeared on the contralesional side. That is, when he was first cued to the ipsilesional side he showed a disproportionate cost to disengaging from that side and reorienting his attention contralesionally (Posner et al., 1984). However, when the pointing cue was inverted, RH showed no validity effects across either side (as happened in the arrow cue experiment). Inversion only had an effect for pointing cues and not gaze cues, but this was only evident for patient RH and not the control group, and is consistent with the performance of the parietal damaged patients in Chapter 2. It seems that visual neglect and extinction can account for impaired orienting to pointing and arrow cues, but a ToM deficit can account for the additional lack of spatial orienting to gaze cues in RH suggesting that gaze cues are special in capturing attention, but that the effect is due to interplay between reflexive mechanisms and voluntary higher-order mental state attributions that may be missing in ToM deficits (Teufel et al., 2010). We have shown that patient RH can use a pointing gesture to direct his attention to specific locations on his ‘good’ side, which cannot be explained away by apparent motion of the pointing cue (see Chapter 2) since this effect disappears with inversion of the cue. Further experiments with more socially meaningful stimuli (realistic gaze and pointing hand) and a better-controlled realistic pointing cue will help us to delineate the social from the symbolic properties of these types of cue, and thus how they are processed in the presence of a ToM deficit.

PART II:

REALISTIC SOCIAL CUES

4.13 Introduction

To investigate RH's performance with more realistic social stimuli, the same cueing stimuli as those described in Chapter 3 were used. If RH's deficit is caused by an inability to extract meaningful information from eye gaze shifts, then there should also be no cueing effect for realistic faces. Also, if it is 'gaze following' specifically and not 'social orienting' generally that is deficient in ToM, we would expect RH to be able to use the subtle pointing gesture to direct attention as well as controls if this requires no interpretation of mental state. Both RH and controls should show no difference between subtle pointing cue and hand cue, if these cues do not require an intact ToM to enable them to be interpreted. There may be differences in performance for RH with Hand and Arrow cues if the pointing hand is represented as a social cue. The same realistic social cue experiments from Chapter 3 were carried out with patient RH and a different group of age-matched controls in order to address the question of how much cueing is 'spatial', and how much is 'social'.

4.14 Methods

4.14.1 Participants

Patient RH completed all of the experiments in this section. In addition five neurologically intact male controls were recruited through a volunteer panel at the University of Birmingham. The controls were age-matched to patient RH as closely as possible (mean age 77.6 years; SD 3.05; age range 73 – 80 yrs) but were all right handed due to the lack of left-handed males within the required age range on the volunteer panel. Please note that these controls were different to those who took part in Experiments 7 – 9, and that RH's age at the time of completing the following experiments was 75 years (i.e. 2 years after completing the previous experiments)

4.14.2 Design

The design for Experiments 10, 11 and 12 is the same as that of Experiment 1. See section *2.2.2 Design* in Chapter 2 for details.

4.14.3 Procedure

The procedure for Experiments 10, 11 and 12 was the same as for Experiment 7. See section *4.2.3 Procedure* in this Chapter for details.

Experiment 10: Upright vs. Inverted Realistic Eye Gaze Cues

4.14.4 Materials

The stimuli for this experiment were exactly the same as for Experiment 4 (see section *3.2.4 Materials* in Chapter 3).

4.15 Results

Within the control group, misses and anticipatory responses (0.07% and 0.19% of total data set, respectively) were removed from the data. RTs outside of 2 SDs of the mean (3.22% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition in each experiment. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (5.48% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs for each experiment.

4.15.1 Controls vs. Patient RH – ipsilesional targets

The analysis revealed a significant main effect of Group (*F* (1, 7) = 312.481, *p* < .001; Controls 396ms, RH 670ms), but no other main effects or interactions approached significance (all *p*s > .100). It is important to note here that when the data are analysed separately for the controls and RH, the pattern of performance is very different. For the control group, there is a significant main effect of Validity (*F* (3, 12) = 7.176, *p* = .005 which interacted with the Orientation factor (*F* (3, 12) = 10.595, *p* = .001. Bonferroni-corrected comparisons between the Validity conditions for the Upright gaze cues showed location-specific cueing effects, with faster RTs following

Same Location (367ms) cues than Same Side (393ms, p = .015) cues, and no significant difference in RTs between Same Side and Neutral (394ms, p > .999) cues. However, for the Inverted gaze cues, Bonferroni-corrected comparisons revealed no significant difference in RTs between any of the Validity conditions (Same Location 407ms, Same Side 405ms, Opposite Side 404ms, Neutral 394ms; all ps > .403). For the analysis of patient RH's data, there were no significant main effects or interactions (all ps > .128; see Figure 40).

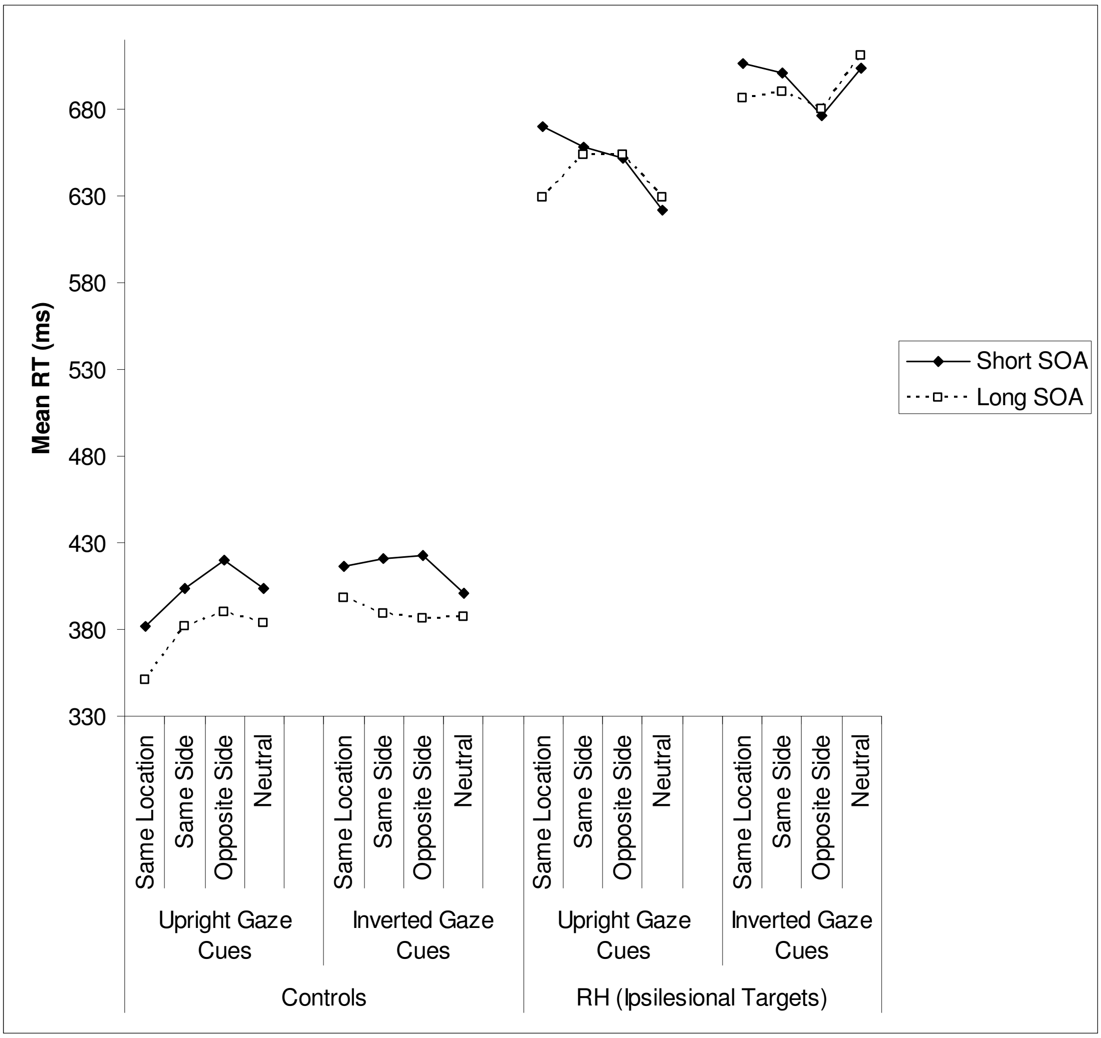

Figure 40. Illustration of Validity effects at both SOAs for the controls and patient RH (ipsilesional targets) in the Upright and Inverted Gaze cue experiments.

4.15.2 Controls vs. Patient RH – contralesional targets

The analysis revealed a significant main effect of Group (*F* (1, 7) = 495.725, $p < .001$; Controls 396ms, RH 684ms), and significant interactions between Orientation and SOA (*F* (1, 7) = 6.319, $p = .040$) and Orientation, SOA and Group (*F* (1, 7) = 6.024, $p = .044$). There was no significant effect of Validity (see Figure 41), and no interactions involving this factor (all *p*s > .140). The

Orientation by SOA by Group interaction was decomposed by separate 2 (Group: Controls, RH) * 2 (SOA: Short, Long) ANOVAs per Orientation (Upright, Inverted). For the Upright gaze cues, there was a main effect of SOA (*F* (1, 7) = 16.006, *p* = .005; short 544ms, long 522ms). For the Inverted cues, there was no main effect of SOA (*p* = .938) but a significant SOA by Group interaction (*F* (1, 7) = 6.127, *p* = .043), where the SOA effect approached significance for the control group (short 415ms, long 390ms; *p* = .097), but not for patient RH (short 681ms, long 705ms; *p* = .152. Note also that this trend is in the opposite direction to the normal SOA effect).

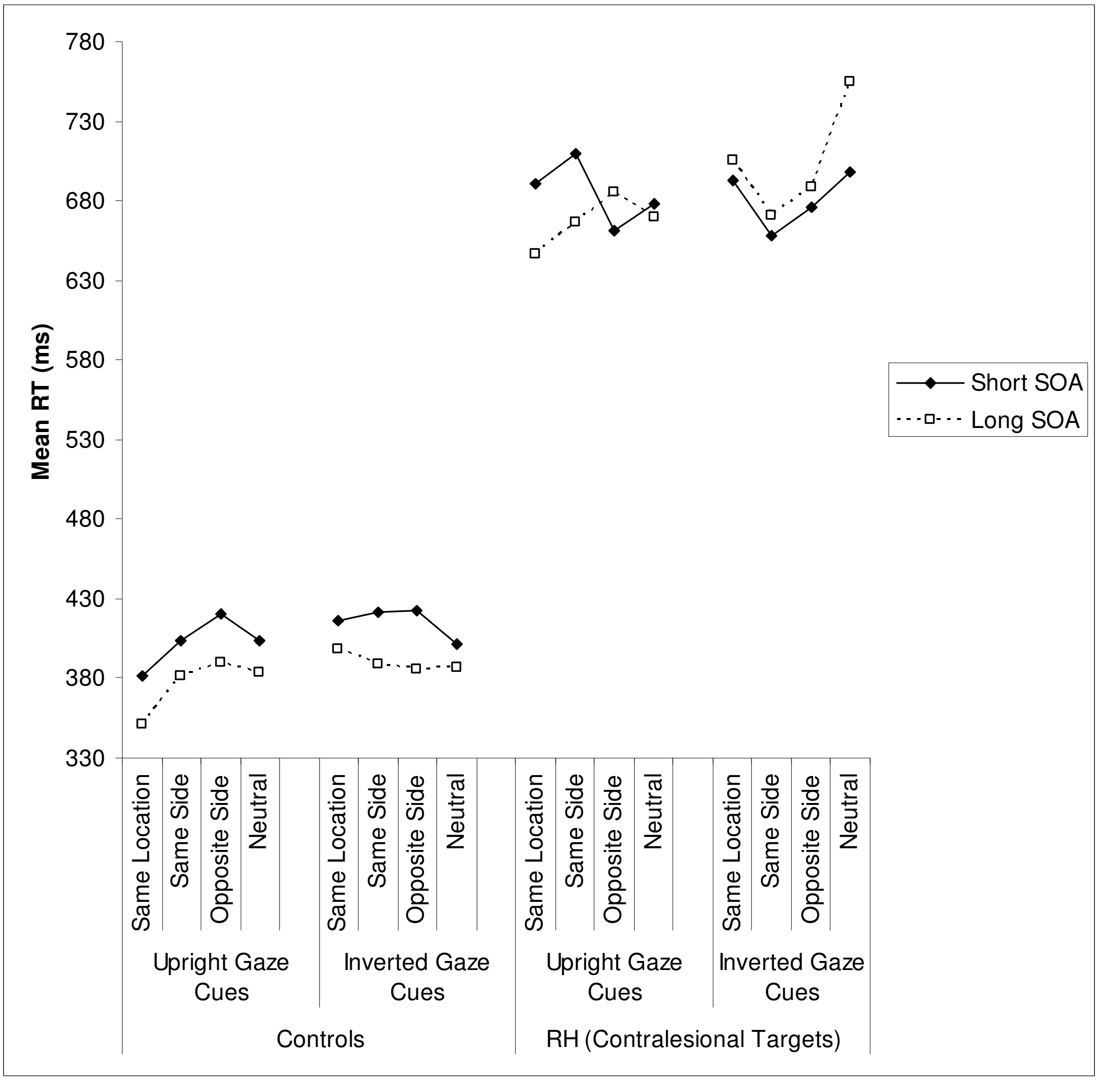

Figure 41. Illustration of Validity effects at both SOAs for the controls and patient RH (contralesional targets) in the Upright and Inverted Gaze cue experiments.

4.15.3 Patient RH

The data from the four experimental sessions with patient RH were entered into a 2 (Orientation: Upright Gaze, Inverted Gaze) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: Short, Long) within-subjects ANOVA. The analysis revealed no significant main effects or interactions (all *p*s > .128). The only effect to approach significance was Side (*F* (1, 3) = 6.626 *p* = .082; ipsilesional 661ms, contralesional 694ms).

4.16 Discussion

Controls show location-specific cueing effects across SOAs for the upright realistic gaze cues, which supports the findings from the previous control group (see Chapter 3). However, there was no significant cueing effect for the inverted gaze cue in this control group. Since there were no inversion effects for the schematic gaze cue in Experiment 7, this suggests that presenting a more realistic (and hence more visually complex gaze cue) does recruit different processing mechanisms and hence inversion disrupts cue validity effects (cf. Tipples, 2005). It is surprising that inversion effects have been found in this control group, and not in the previous control group in Chapter 3. Since there was no cueing effect of inverted gaze cues in the present control group, but there was in the control group presented in Chapter 3, the results could be due to the smaller sample size of the group presented here, rendering it less sensitive to detecting a more subtle effect. Nevertheless, what is most pertinent to our research questions is the performance of RH. Consistent with his performance with schematic gaze cues in Experiment 7, RH showed no cueing effects in response to more realistic, photographic gaze cues, regardless of cue orientation. This is again consistent with classic accounts of gaze following underpinning ToM (Baron-Cohen, 1995) and supports the notion of gaze mechanisms being influenced by perceived mental state-attribution in normal observers (Teufel et al., 2010).

Experiment 11: Upright vs. Inverted Realistic Pointing Across the Body Cues

4.17.1 Materials

The stimuli for this experiment were the same as for Experiment 5 (see section *3.5.1 Materials* in Chapter 3).

4.18 Results

Within the control group, misses and anticipatory responses (0.08% and 0.12% of total data set, respectively) were removed from the data. RTs outside of 2 SDs of the mean (5.22% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition in each experiment. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (5.79% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs for each experiment.

4.18.1 Controls vs. Patient RH – ipsilesional targets

The analysis showed significant main effects of Group (*F* (1, 7) = 641.511, *p* < .001; Controls 398ms, RH 657ms) and SOA (*F* (1, 7) = 26.281, *p* = .001; short 540, long 515ms). There was a significant interaction between Orientation and Validity (*F* (3, 21) = 3.393, *p* = .037), which was decomposed by Bonferroni-corrected comparisons between the Validity conditions for each cue Orientation. For the Upright point across the body cues, there were location-specific cueing effects with faster RTs following the Same Location (503ms) cues than the Same Side (543ms, *p* = .011) cues, and no significant difference in RTs between the Same Side and Neutral (531ms, *p*

> .999) conditions. However, for the Inverted point across the body cues there was no significant differences between RTs in any Validity conditions (Same Location 527ms, Same Side 528ms, Opposite Side 525ms, Neutral 516ms; all *p*s > .999), which shows that this cue afforded no cueing effects (see Figure 42).

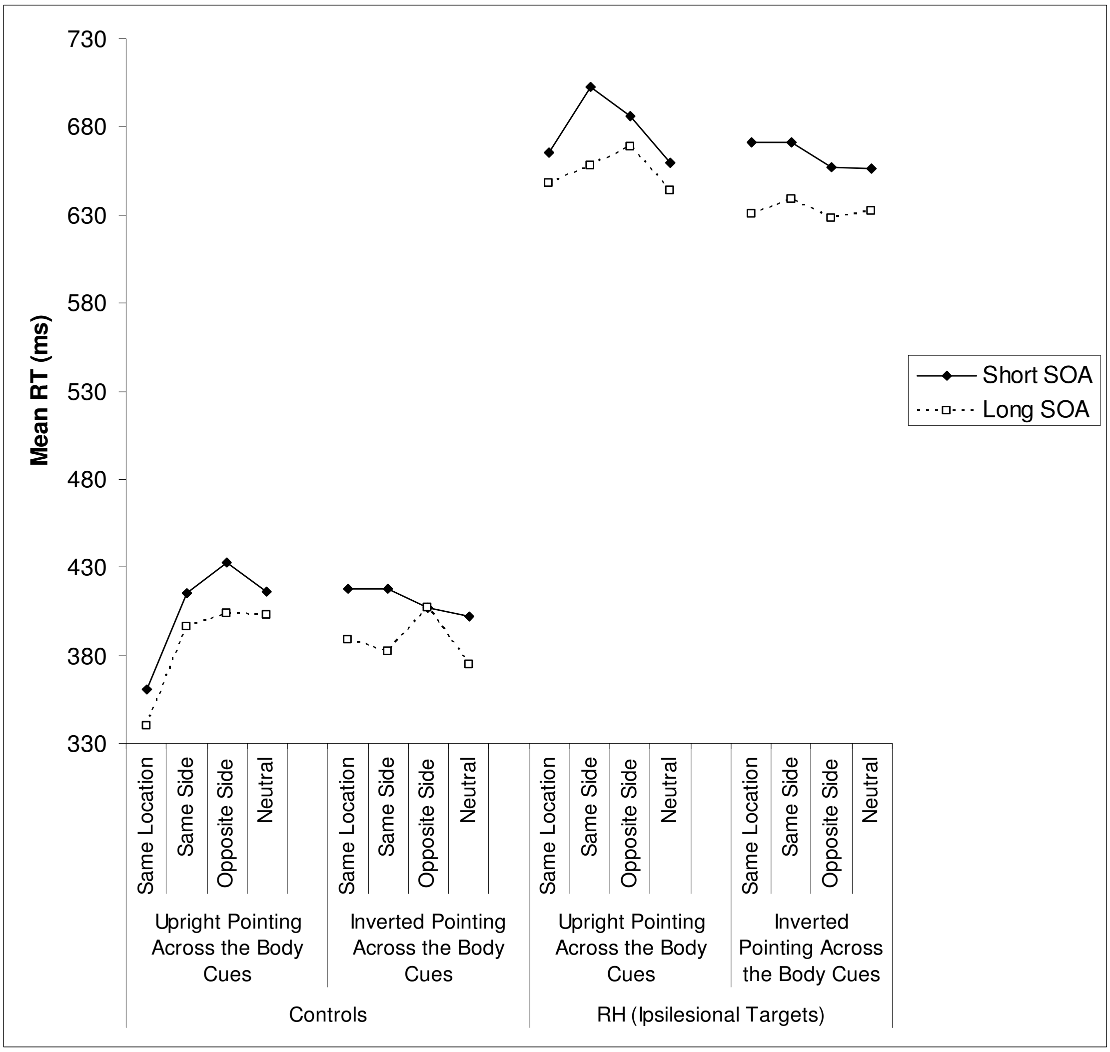

Figure 42. Illustration of Validity effects at both SOAs for the controls and patient RH (ipsilesional targets) in the Upright and Inverted Pointing Across the Body cue experiments.

4.18.2 Controls vs. Patient RH – contralesional targets

The analysis showed significant main effects of Group (*F* (1, 7) = 429.556, *p* < .001; Controls 398ms, RH 662ms) and Validity (*F* (3, 21) = 11.477, *p* < .001), which were qualified by a significant interaction (*F* (3, 21) = 7.097, *p* = .002). In addition there were significant interactions between SOA and Group (*F* (1, 7) = 16.196, *p* = .005), and Orientation and Validity (*F* (1.3, 9.3) = 7.444, *p* = .018), which were qualified by a significant four-way interaction between Orientation, Validity, SOA and Group (*F* (3, 21) = 5.663, *p* = .005). This was decomposed by separate 2 (Orientation: Upright Point, Inverted Point) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: Short, Long) within-subjects ANOVAs per group (controls, patient RH).

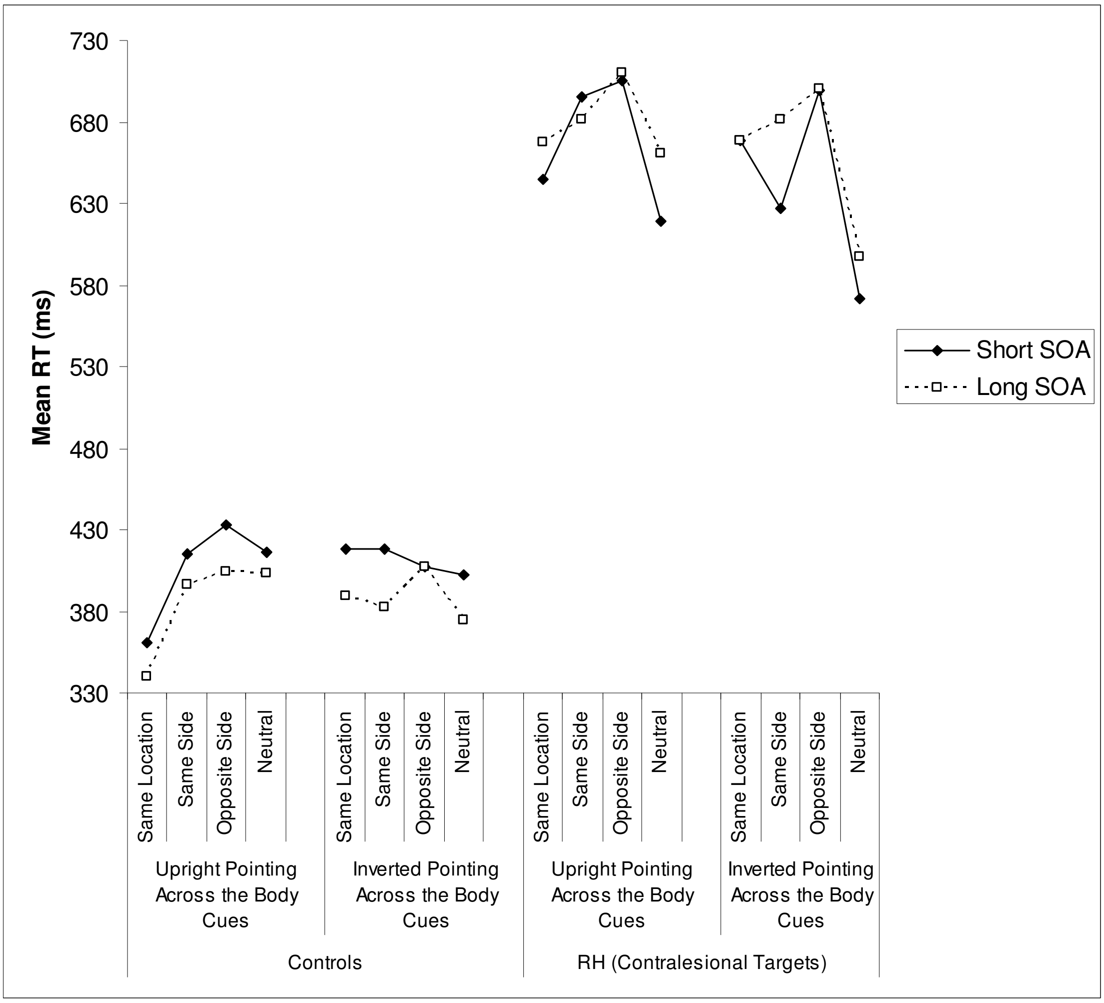

Figure 43. Illustration of Validity effects at both SOAs for the controls and patient RH (contralesional targets) in the Upright and Inverted Pointing Across the Body cue experiments.

For the control group, the analysis showed significant main effects of Validity (*F* (3, 12) = 11.305, *p* = .001) and SOA (*F* (1, 4) = 37.039, *p* = .004; short 409ms, long 387ms), and a significant interaction between Orientation and Validity (*F* (3, 21) = 30.589, *p* < .001). Bonferroni-corrected comparisons between the Validity conditions for each cue Orientation showed the same pattern of validity effects as described in the previous section. That is, for

Upright point across the body cues there were significant location-specific cueing effects with faster RTs following the Same Location (351ms) cues than the Same Side (406ms, p = .045) cues, and no significant difference in RTs between the Same Side and Neutral (410ms, p > .999) conditions. However, for the Inverted point across the body cues there was no significant differences in RTs between any Validity conditions (Same Location 404ms, Same Side 400ms, Opposite Side 407ms, Neutral 389ms; all *p*s > .381). For patient RH the analysis showed a significant main effect of Validity (*F* (3, 9) = 7.230, p = .009), although Bonferroni-corrected comparisons showed that the only significant difference in RTs was between Opposite Side (703ms) and Neutral (612ms, p = .028) validity conditions. All other differences did not approach significance (all *p*s > .472).

4.18.3 Patient RH

The data from the four experimental sessions with patient RH were entered into a 2 (Orientation: Upright Point across cue, Inverted Point across cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: Short, Long) within-subjects ANOVA. The analysis revealed a significant main effect of Validity (*F* (3, 9) = 6.001, p = .016), where Bonferroni-corrected comparisons showed that the only significant difference in RTs was between Opposite Side (682ms) and Neutral (630ms, p = .045) validity conditions. All other differences did not approach significance (all *p*s > .266).

4.19 Discussion

Controls showed location-specific cueing effects for upright but not inverted pointing across the body cues, across SOAs. This is consistent with reflexive orienting for the both cues, but only location-specific for upright cues. These results differ slightly from those obtained by the previous control group reported in Chapter 3, where there were no location-specific effects across cue orientations, but general shifts to the correct side. Nonetheless the results from our control group here show that the more subtle pointing cue can indeed serve to reorient attention reflexively in normal observers. Similar effects have been reported many times in the literature for gaze and arrow cues (e.g. Ristic et al., 2002; Tipples, 2002). On the other hand, patient RH showed no significant cueing effects in response to either the upright or the inverted subtle pointing cues. The only difference overall between the cueing conditions was a general slowing of responses to invalid cues relative to neutral cues. Since patient RH could not use eye gaze cues to direct his attention due to his ToM deficit, the finding that he can also not use pointing gestures to cue his attention implies that these gestures also require the attribution of mental-states to render them useful directional cues. However, this speculation will be clarified by RH’s performance when cued by a pointing hand alone. If the hand is perceived as belonging to another person (even in the absence of a body) then a mental state must be attributed and hence RH will not be able to make use of this cue either. However, if the hand is not associated with the human body, and thus as a symbolic directional cue (like an arrow) then RH will be able to use this directional information to shift his own attention.

Experiment 12: Realistic Pointing Hand Cues

4.20.1 Materials

The stimuli for this experiment were the same as for Experiment 6 (see section 3*.8.1 Materials* in Chapter 3).

4.21 Results

Within the control group, misses and anticipatory responses (0.07% and 0.15% of total data set, respectively) were removed from the data. RTs outside of 2 SDs of the mean (5.13% of total data set) were removed, and a cell mean was calculated from the remaining RTs for each condition in each experiment. For patient RH, there were no misses or anticipatory responses. RTs outside of 2 SDs of the mean (5.98% of total data set) were removed, and a cell mean was calculated for each condition in each of the 4 runs for each experiment.

4.21.1 Controls vs. Patient RH – ipsilesional targets

The analysis showed significant main effects of Group (F (1, 7) = 62.094, $p < .001$; Controls 419ms, RH 625ms), Validity (F (3, 21) = 14.810, $p < .001$), and SOA (F (1, 7) = 15.542, p = .006; short 536ms, long 509ms). Bonferroni-corrected comparisons between the Validity conditions showed location-specific cueing effects with faster RTs for Same Location (482ms) than Same Side (525ms, p = .002), and no significant RT advantage for Same Side cues over Neutral cues (530ms, $p > .999$; see Figure 44), which is consistent with reflexive location-specific cueing.

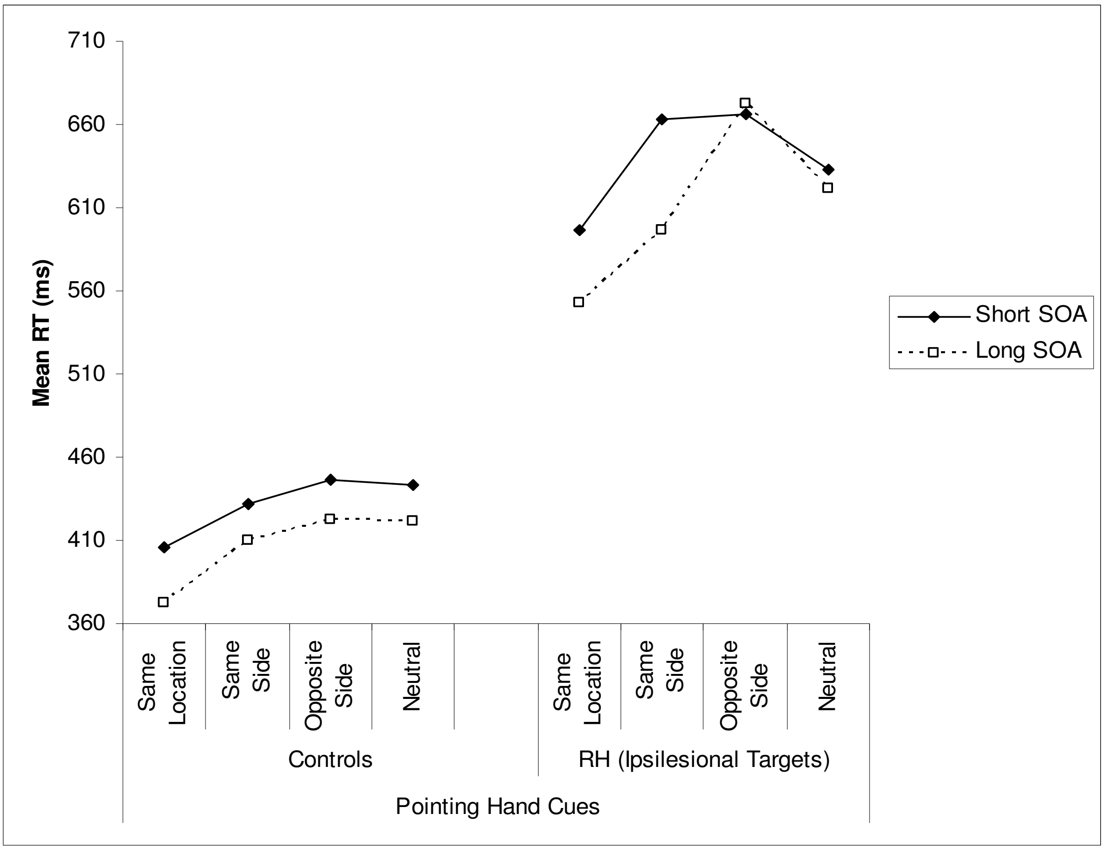

Figure 44. Illustration of Validity effects at both SOAs for the controls and patient RH (ipsilesional targets) in the Pointing Hand cue experiments.

4.21.2 Controls vs. Patient RH – contralesional targets

The analysis showed significant main effects of Group (*F* (1, 7) = 45.748, *p* < .001; Controls 419ms, RH 625ms) and Validity (*F* (3, 21) = 30.674, *p* < .001), which were qualified by a significant interaction (*F* (3, 21) = 8.710, *p* = .001). Bonferroni-corrected comparisons between the Validity conditions for the control group showed no statistically significant validity effects for the hand cue, (Same Location 389ms, Same Side 421ms, Opposite Side 435ms, Neutral 432; all *p*s > .080). This is odd, since the same data was entered into the previous analysis which showed location-specific cueing effects. However, this may be due to the relatively modest validity effects in the control group being boosted by the greater magnitude of cueing effect in RH. For patient RH the Bonferroni-corrected comparisons showed evidence of location-specific cueing with faster RTs for Same Location (572ms) cues than Same Side (657ms, $p = .004$), and no RT advantage for Same Side cues over Neutral (616ms, $p = .112$). However, the analysis also showed that there was no difference in RTs between Same Location (572ms) and Neutral (616ms, $p = .120$) cues, and that the Opposite Side (691ms) cues elicited significantly slower RTs than all other validity conditions (all *p*s < .009). This suggests that the significant effect of Validity we see with patient RH is driven by a disengage deficit when he is first cued (invalidly) to his ipsilesional side (see Figure 45).

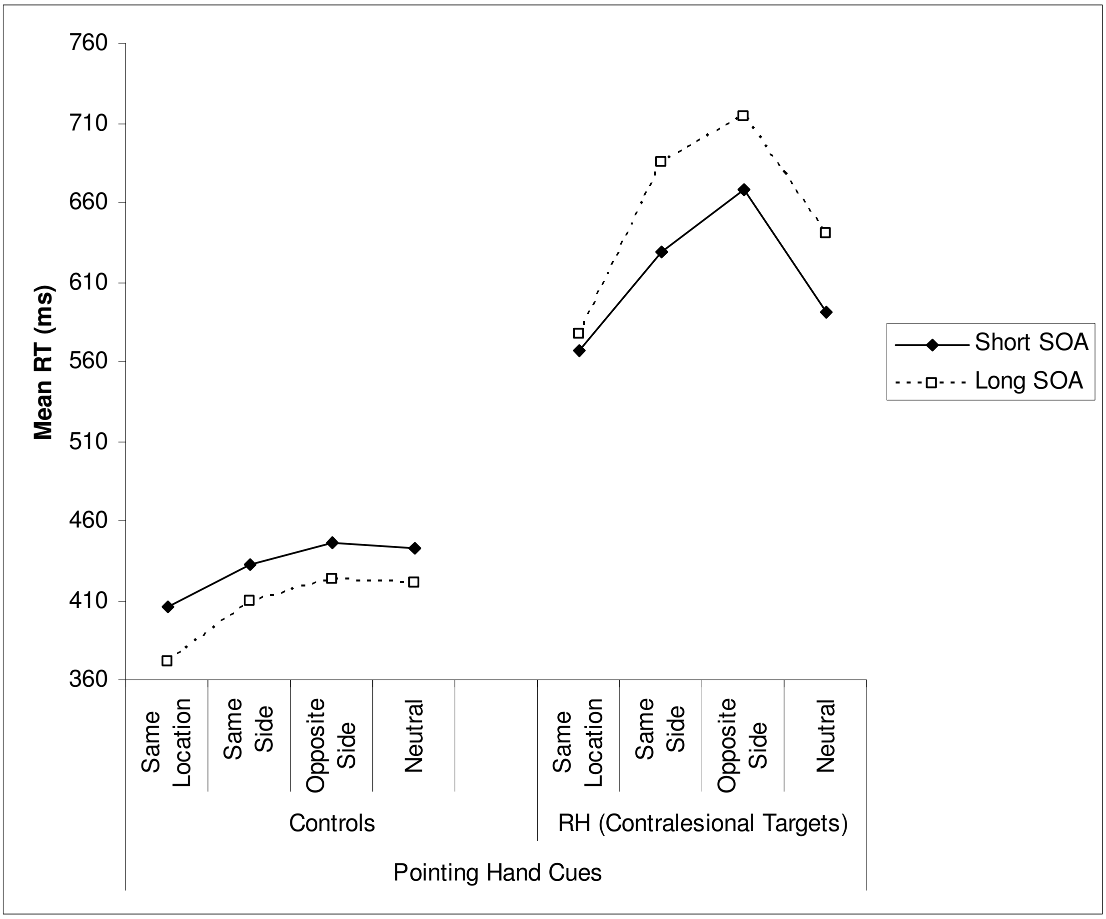

Figure 45. Illustration of Validity effects at both SOAs for the controls and patient RH (contralesional targets) in the Pointing Hand cue experiments.

4.21.3 Patient RH

The data from the four experimental sessions with patient RH were entered into a 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: Short, Long) within-subjects ANOVA. The analysis revealed a significant main effect of Validity (F (3, 9) = 22.181, $p < .001$), and a significant interaction between Side and SOA (F (1, 3) = 23.252, $p = .017$). This interaction occurred because at the short SOA there was no significant effect of Side (MD 26ms, *p* = .129), but at the long SOA ipsilesional targets (614ms) were detected significantly faster than contralesional targets (654ms, *p* = .030). Bonferroni-corrected comparisons between the Validity conditions showed location-specific cueing effects where Same Location (573ms) cues elicited significantly faster RTs than Same Side (643ms, *p* = .027) cues, and there was no RT benefit for Same Side cues over Neutral (621ms, *p* = .388) cues.

4.22 Discussion

The results show that the control group and patient RH show location-specific cueing effects in response to the hand cue. For patient RH there is also evidence of a disengage deficit associated with contralesional target detection, which is consistent with parietal damage (Posner et al., 1984) and a disproportionate cost of reorienting attentional contralesionally when it is first cued ipsilesionally. With regards to his performance relative to previous experiments, RH's pattern of results show that when presented alone, the pointing hand cue is not associated with the human body (or at least not attributed a mental state) and thus reorients attention normally. However, the hand cue afforded a location specific cueing effect in RH, whereas the arrow cue only served a general shift of attention to the correct versus incorrect side. Since RH could use the hand cue to overcome his spatial orienting deficit, but could not do the same for the subtle pointing cue, this suggests that the latter cue must hold some social relevance that cannot be decoded by RH due to his ToM deficit. This is further support for our suggestion that human pointing cues do hold some salience with regards to their social nature, and can reorient attention reflexively to specific locations in normal observers.

4.23 Cross Experiment Analyses

To investigate differences in the magnitude of validity effects between the pointing cues, separate analyses were carried out, similar to the analyses in Chapter 3. Note that as in the previous cross-experiment analyses within this chapter, RH did not show a cue validity effect for the schematic gaze cue, and so his performance in the gaze experiment was not directly compared to his performance in the pointing cue experiments to avoid unnecessary repetition.

Exploring Effects of Different Pointing Gestures

Data were entered into a 2 (Group: Controls, RH) * 2 (Cue type: Hand cue, Upright Pointing cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA.

Controls vs. RH – Ipsilesional Targets

The analysis showed significant main effects of Group (*F* (1, 7) = 30.564, *p* = .001; Controls 424ms, RH 601ms) and Validity (*F* (3, 21) = 30.786, *p* < .001) which were qualified by a significant interaction (*F* (3, 21) = 3.731, *p* = .027; see Figure 46). For the control group and for RH, Bonferroni-corrected comparisons between the Validity conditions (across cue types) showed that Same Location cues (Controls 396ms, RH 545ms) elicited significantly faster RTs than Same Side cues (Controls 431ms, *p* = .049; RH 611ms, *p* = .003), and that there was no RT benefit for Same Side cues over Neutral cues (Controls 430ms, RH 609ms, both *p*s > .999). However, the interaction occurs because for the control group there was no significant difference in RTs between Same Side (541ms) and Opposite Side cues (546ms, *p* > .999), but this difference was significant for patient RH (Same Side 611ms, Opposite Side 641ms, *p* = .049). This reinforces the evidence for RH's disengage deficit, where his between-field shifts of attention are much slower than within-field shifts. Importantly for this analysis, there were no interactions with the Cue Type factor, which shows that the Validity effects were the same for both the Hand and Pointing cues, suggesting that similar mechanisms are employed in the processing of these cues.

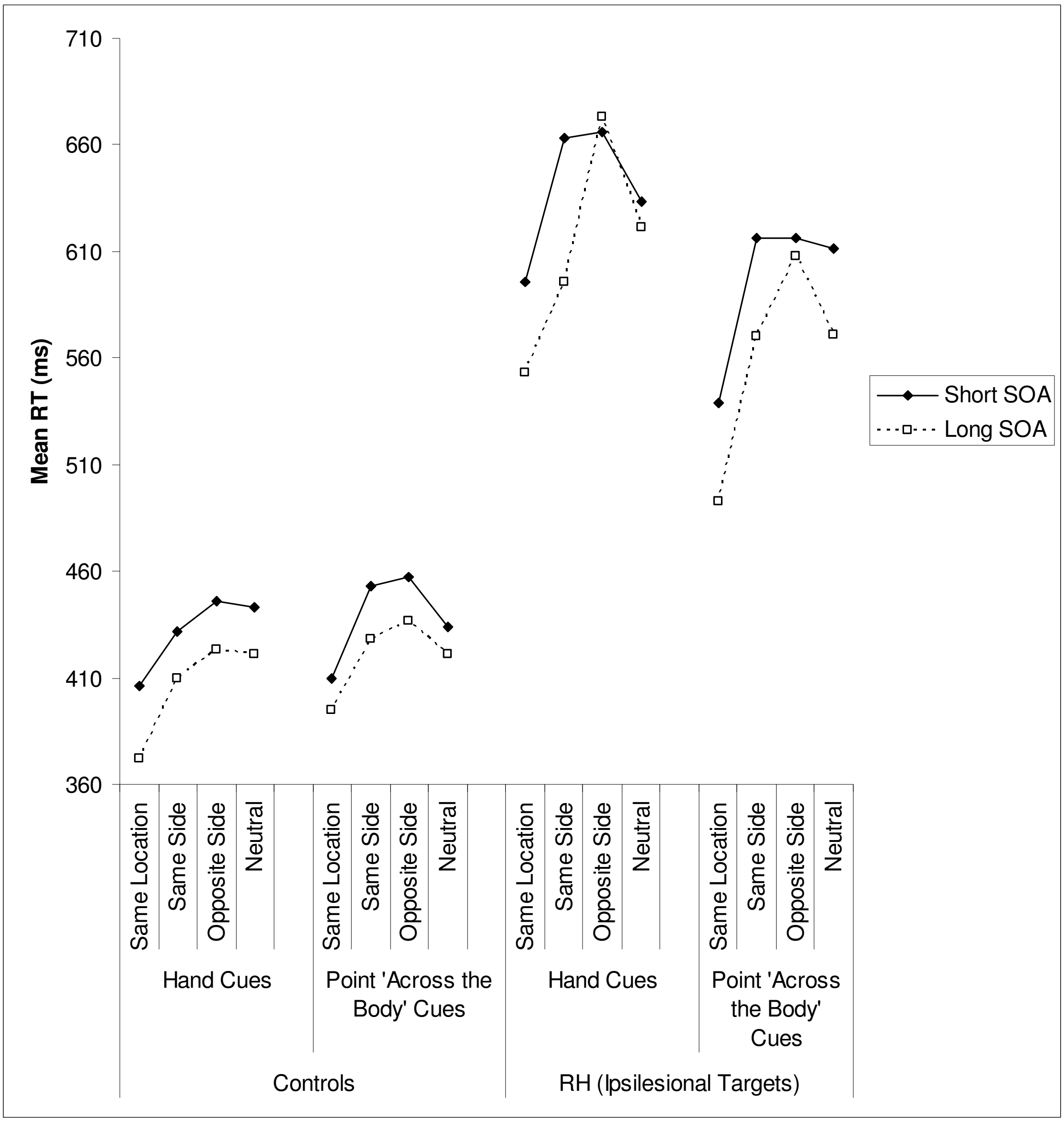

Figure 46. Illustration of Validity effects in the Hand and upright Pointing cues between the age-matched controls and patient RH (ipsilesional target detection).

Controls vs. RH – Contralesional Targets

The analysis showed significant main effects of Group (*F* (1, 7) = 35.872, *p* = .001; Controls 424ms, RH 622ms) and Validity (*F* (3, 21) = 44.400, *p* < .001) which were qualified by a significant interaction (*F* (3, 21) = 13.313, *p* < .001). As described previously, both controls and RH showed location-specific cueing but the interaction is driven by different magnitudes of the effect between the groups. In addition there was a significant interaction between Cue Type, SOA and Group (*F* (1, 7) = 6.258, *p* = .041) which was decomposed by separate 2 (Cue type: Hand cue, Upright Outstretched Pointing cue) * 2 (SOA: short, long) within-subjects ANOVAs per group (see Figure 47). For the control group there was a significant effect main effect of SOA (*F* (1, 4) = 9.486, *p* = .037) which interacted with Cue Type (*F* (1, 4) = 37.312, *p* = .004) showing a stronger effect of SOA for the Hand cue than the subtle pointing cue (Hand: short 432, long 407ms, *p* = .029; Pointing: short 439, long 420ms, *p* = .050). However, for patient RH none of the effects or interaction approached significance (*p* > .130).

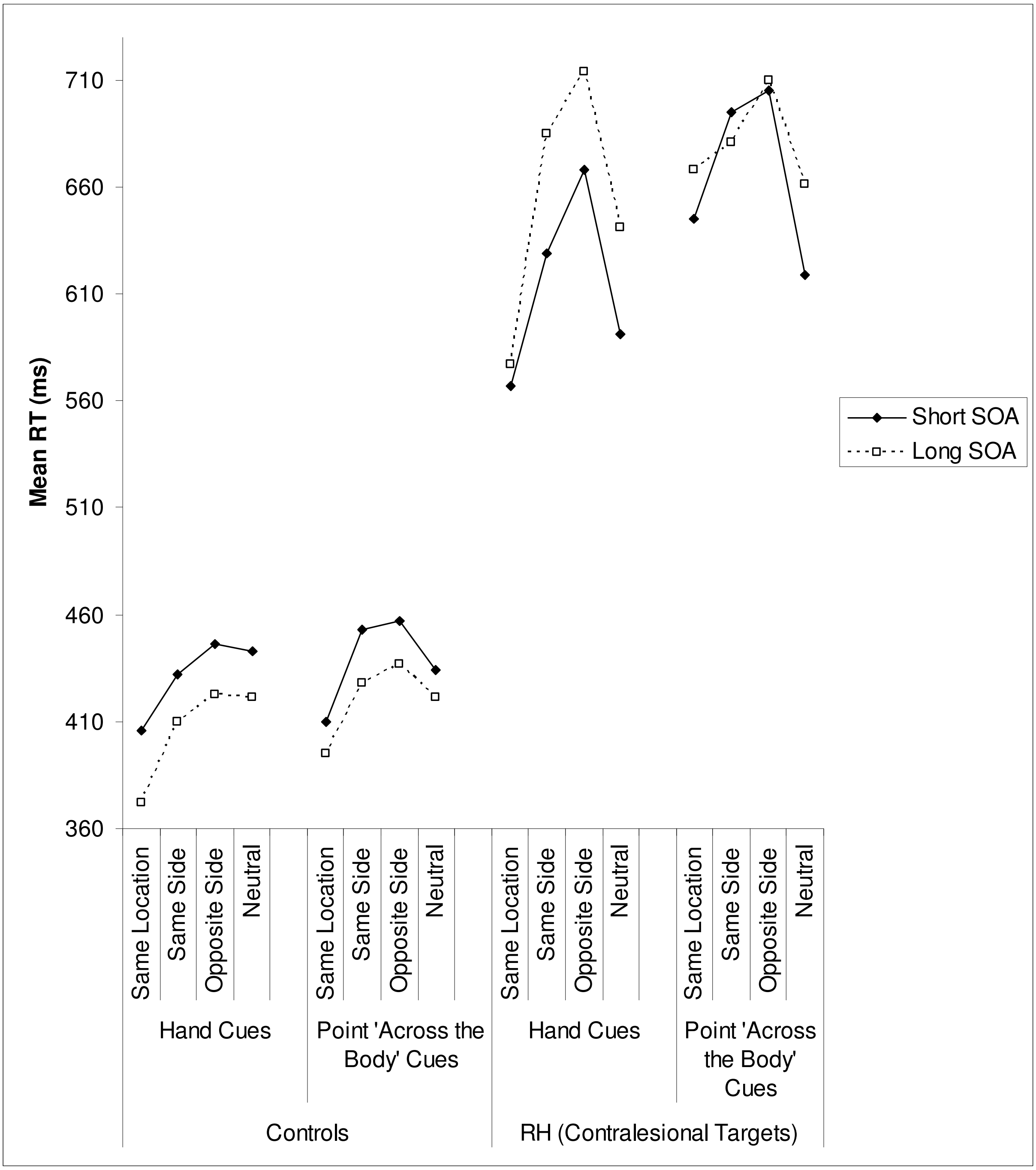

Figure 47. Illustration of Validity effects in the Hand and upright Outstretched Pointing cues between the age-matched controls and patient RH (contralesional target detection).

4.24 Main Discussion

Patient RH showed no significant cueing effect in response to the realistic eye gaze shifts or to subtle pointing gestures made in the context of the whole body. We propose that this is evidence that pointing gestures rely on mental-state attribution of the observer to the 'pointer', and as such that pointing cues can invoke joint attention in much the same way as perceived eye gaze direction (supporting Baron-Cohen et al., 1996). There has been no research to date on covert orienting in response to pointing gestures in acquired ToM patients, and so this finding extends theories developed in the neurodevelopmental literature to explain deficits in neuropsychological cases (e.g. Apperly et al., 2004). However, it is important to bear in mind the shortcomings of single case methodologies, with specific reference to the interpretation and generalisation of results. In cases where data from single cases are compared to that of a small control group, there is a danger of an inflated Type I error, with an overestimation of the abnormality of a patients' score. However, we have tried to minimise this bias by incorporating data from multiple sessions into our analysis of the single-case patient data, to allow greater confidence that the observed effect is relatively stable across time. Unfortunately the use of non-parametric statistic analyses was not an option, since there were no suitable tests which could account for the relatively large number of experimental factors in our studies. In addition, there has also been no published research on covert orienting in response to pointing gestures in adults with autism. Previous studies have shown that normally developed adults who display a high proportion of autistic personality traits actually perform similarly to autistic individuals on certain cognitive tasks (Stewart et al., 2009). Further, Bayliss and Tipper (2005) showed that these effects extend to similarities in social orienting mechanisms between autistic individuals and those who display autistic 'traits'. Therefore, in Chapter 5 the realistic gaze and pointing experiments will be carried out with a group of adults who show a higher than average proportion of autistic personality traits, to further examine the extent to which pointing cues can reorient covert attention in autism.

CHAPTER 5:

THE EFFECT REALISTIC SOCIAL CUES ON THE REORIENTING OF VISUAL ATTENTION IN PARTICIPANTS WITH AUTISTIC PERSONALITY TRAITS

5.1 Introduction

The development of the Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001) has allowed researchers to understand autistic-type behaviour in the normal population, without the confounds of language or learning disorders that are typical in autism spectrum disorders (ASD; Stewart et al., 2009). Bayliss and Tipper (2005) used the AQ as a tool for dividing normally developing participants into high and low scoring groups and found differences between the groups in a cued detection task. The low-scoring AQ group showed greater cueing towards targets that appeared on faces, whereas the high-scoring group were more strongly cued for targets appearing on scrambled faces. These effects were constant across gaze and arrow cues for each group, where Bayliss and Tipper (2005) argue that akin to ASD individuals, the high scoring group were biased towards non-social stimuli. In ASD, there appears to be a bias for local over global processing, which has been explained by ‘weak central coherence’ (Happé & Frith, 2006) and a strong tendency to ‘systemise’ (Baron-Cohen, 2002). The findings of Bayliss and Tipper (2005) support studies which have shown no difference in the cueing effects of gaze and arrows in normal observers (Tipples, 2002; Ristic et al., 2002), and have shown that this effect extends to the wider autistic phenotype. Bayliss and Tipper’s (2005) differential effects between high and low AQ scorers was in attentional orienting *towards* social and non-social stimuli, and is hence slightly different to reorienting attention in response to such stimuli which has been investigated thus far in this thesis. Nevertheless, this finding has demonstrated that individual differences in autistic-type traits can affect social orienting styles in the normal population, and as such provides the rationale for the following study.

The experiments presented in the following chapter were carried out with undergraduate student participants who were selected on the basis of their score in relation to the group mean on the Autism-Spectrum Quotient (Baron-Cohen et al., 2001). Since autistic individuals tend to have difficulties in using eye-gaze cues (i.e. the EDD module in Baron-Cohen's 1995 model) to direct attention to events or stimuli in the environment (Baron-Cohen et al., 1996) we wanted to investigate whether this deficit would a) be apparent in high scoring AQ participants, b) how this would compare to performance with inverted gaze cues, and c) whether these cueing effects would extend to human pointing gestures (i.e. could the SAM be engaged by gestures which are independent of the EDD). In summary, the following series of experiments explored whether autistic personality traits in a normal population would influence the effectiveness of human social cues in a target detection paradigm. Based on the findings of Langton and Bruce (1999) we would expect inversion of the gaze cue to disrupt the cueing effects in the low AQ group (i.e. in line with the effects of normal participants), but the research from Swettenham et al. (2003) allows us to predict that this inversion of the gaze cue will not affect gaze cueing in the high AQ group (i.e. akin to ASD individuals). If pointing cues are indeed processed in a similar way to gaze cues, then the inversion effects found with gaze cues should be mirrored by effects found with upright and inverted pointing cues. However, if pointing cues are processed in a similar way to symbolic arrows and the associated cue-validity effects are insensitive to inversion, then there should be no effect of cue orientation for any of the pointing cues. Similarly, if pointing cues do not have the same socio-biological relevance to attention as eye gaze cues, then there should be no difference in the magnitude of the cueing effects the different types of pointing cue.

5.2 Methods

5.2.1 Participants

The participants were all undergraduate psychology students at the University of Birmingham. The AQ (Baron-Cohen et al., 2001) was made available as an online questionnaire via a research participation website administered by the School of Psychology at University of Birmingham. A total of 311 students completed the AQ (30 males, 281 females; aged between 18-37 years, mean age 19.1 years, SD = 1.9) and were offered participation credits for their time. The scores were collated and the descriptive statistics showed that the scores ranged from 4 to 36, with a group mean score of 16 (SD = 5). These scores are in line with the mean scores presented by Baron-Cohen et al. (2001) from a randomly selected control group of students (mean 17.6, SD = 6.4; Baron-Cohen et al., 2001). From our sample of AQ responders, those who scored higher or lower than 1.5 SD from the mean (N = 22 in each group) were invited to take part in the following target detection experiments in return for participation credits or a small cash payment. Of the 22 participants approached, 17 from each group agreed to take part in the experiment. Informed consent was obtained from all participants prior to testing, and the same participants took part in all Experiments in this Chapter.

5.2.2 Design

The design for all Experiments in this chapter is exactly the same as that of Experiment 1. See section *2.2.2 Design* in Chapter 2 for details.

5.2.3 Materials

Autism Spectrum Quotient

The Autism Spectrum Quotient (Baron-Cohen et al., 2001) is a 50-item questionnaire designed to assess the extent to which adults with a normal IQ possess personality traits that are associated with ASD (Autism Spectrum Disorder). There are five subscales within the questionnaire which measure social skills (e.g. I prefer to do things with others rather than on my own), communication (e.g. I enjoy social chit-chat), imagination (e.g. I find making up stories easy), attention to detail (e.g. I often notice small sounds when others do not) and attention switching (e.g. I prefer to do things the same way over and over again), where each subscale is assessed by 10 questions each. Please refer to Appendix III for a full schedule of items on the AQ. There are four possible responses to each question (definitely agree, slightly agree, slightly disagree, definitely disagree) which were scored with either 1 or 0 depending on whether the question is worded to elicit an 'agree' or a 'disagree' response, eliciting a potential range of scores between 0 and 50. The questionnaire was made available online through a research participation website at the University of Birmingham, and participants were offered credits for their time.

5.2.4 Procedure

The procedure was the same for all Experiments in this Chapter. Each participant completed all of the experiments (Experiments 13, 14 & 15). The experiments were randomised across participants during two testing sessions. Four practice trials were included at the start of each experiment to familiarise participants with the stimuli. Each experiment was separated into two blocks to allow rest breaks, with 185 trials comprising one block and a total of 370 trials per experiment.

In each experiment, all participants were instructed to keep their eyes fixated on the centre of the screen, and not to look towards to target locations or targets themselves when they appeared, but simply to press the spacebar whenever they detected a target in their peripheral vision. However when no target was present, the participants were instructed to refrain from making a response and wait for the next trial. Eye movements were monitored periodically, to check that fixation was maintained at the centre of the screen. In addition, at each rest break a written instruction appeared on the computer screen to remind the participants to keep their eyes fixated at the centre of the screen at all times.

Experiment 13: Upright vs. Inverted Realistic Eye Gaze Cues

5.2.5 Materials

The stimuli for this experiment were exactly the same as for Experiment 4 (see section 3*.2.4 Materials* in Chapter 3).

5.3 Results

Each participant contributed 20 raw data points (RTs) per condition in each of the experiments. Misses and anticipatory responses (<100ms) were removed from further analyses. Within each condition, RTs outside of 2 SDs of the mean were removed and a mean RT was calculated from the remaining data for each experiment. For clarity, the percentage of data removed for each experiment is presented in Table 5.

Paired t-tests were performed on the percentage of data removed on account of misses, anticipatory responses, RTs removed after cleansing, and hits made on catch trials (across all experiments) to test for differences between the high and low AQ groups. There was significantly more data removed from the high AQ group than the low AQ group on account of anticipatory responses (1.67% vs. 0.88%; t (4) = 6.048, p = .001) and RTs removed through cleansing (6.21% vs. 5.89%; t (4) = 3.433, p = .014). The high AQ group also made more hits on catch trials than the low AQ group (10.72% vs. 4.74%; t (4) = 11.776, $p < .001$). Finally, there was no significant difference in the proportion of misses made between the high and low AQ groups (0.26% vs. 0.03%, t (4) = 2.343, p = .058).

Table 5. Summary of the percentage of data removed prior to analysis for each experiment, across all participants in each of the AQ groups.

Experiment	AQ Group	Miss	Anticipatory Responses <100ms	RTs removed ± 2SD	Hits on Catch Trials
Experiment 13	High	0.19%	1.33%	6.29%	8.93%
Upright Gaze	Low	0	0.33%	5.13%	3.33%
Experiment 13	High	0.04%	1.25%	6.06%	10.67%
Inverted Gaze	Low	0.02%	0.42%	5.42%	2.67%
Experiment 14	High	0.31%	1.38%	6.04%	9.73%
Upright Point	Low	0.08%	0.58%	10.71%	3.07%
Experiment 14	High	0.25%	2.40%	6.27%	12.27%
Inverted Point	Low	0.02%	0.83%	5.21%	4.27%
Experiment 15	High	0.81%	1.27%	6.27%	10.53%
Pointing Hand	Low	0	0.52%	5.10%	2.93%

All experiments were analysed in broadly the same way. For Experiments 13 and 14, the data were entered into a 2 (AQ group: high score, low score) * 2 (Orientation: Upright cue, Inverted cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: 100ms, 300ms) mixed design ANOVA. For Experiment 15, there was no ‘Orientation’ factor since the cue was a pointing hand, so the data were entered into a 2 (AQ group: high score, low score) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: 100ms, 300ms) mixed design

ANOVA. In all experiments, Orientation, Validity and SOA were within-subjects factors and AQ group was the between-subjects factor.

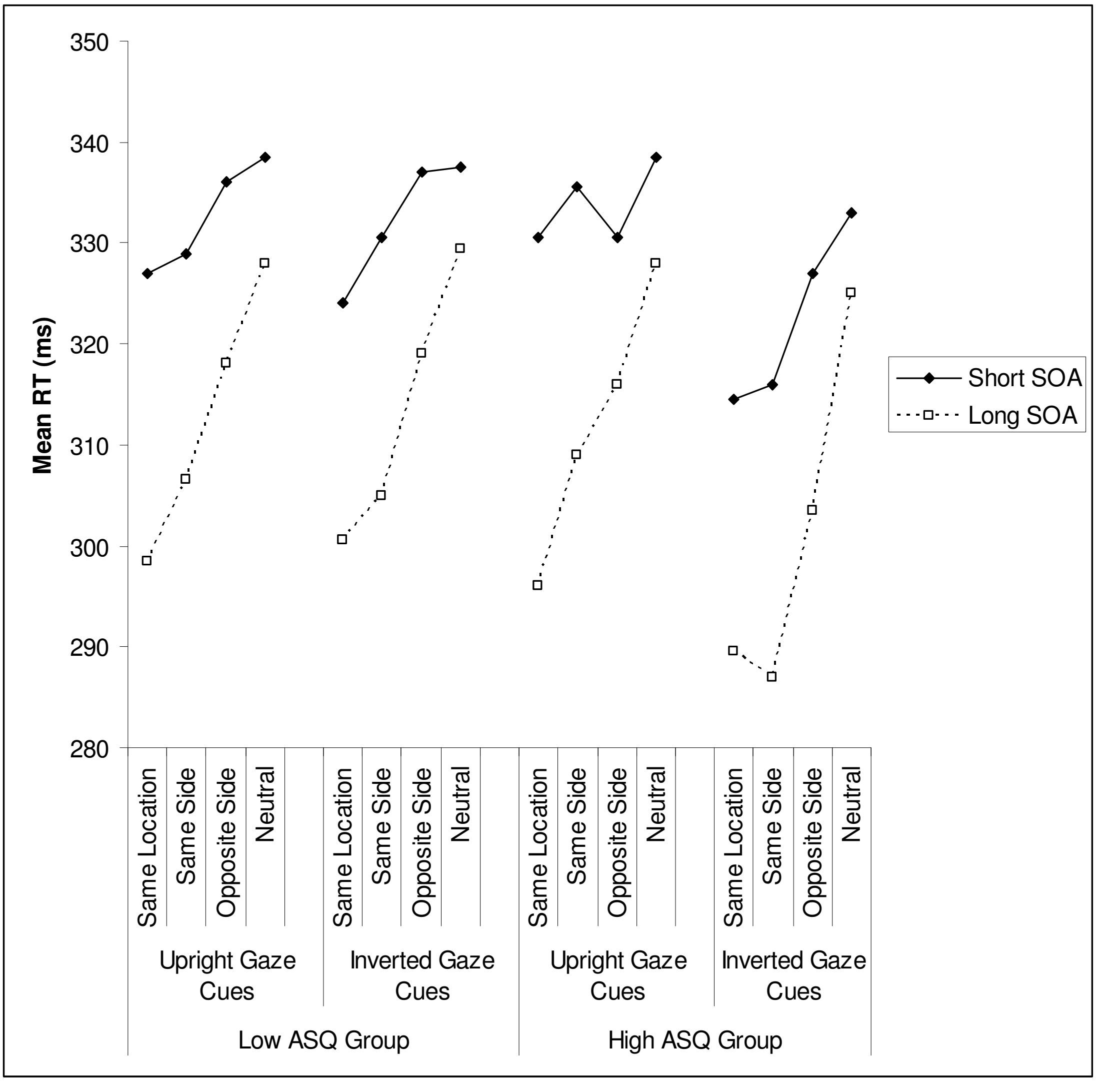

Figure 48. Illustration of all the conditions of the upright and inverted gaze cue experiments, for both the high and low AQ group participants.

For the gaze cues, the analysis revealed that there were no significant main effects of AQ Group (*F* (1, 32) = .202, *p* = .656) or Orientation (*F* (1, 32) = 1.070, *p* = .309). There were significant main effects of Validity (*F* (2.4, 75.2) = 53.667, *p* < .001) and (SOA *F* (1, 32) = 128.870, *p* < .001; short 330ms, long 310ms) which were qualified by a significant interaction (*F* (3, 96) = 12.703, *p* < .001). For the short SOA, Bonferroni-corrected comparisons showed no significant difference between RTs for Same Location (324ms) and Opposite Side (328ms, *p* = .824) cues. [Note that Figure 48 suggests this effect is driven by the high scoring AQ group in the Upright Gaze cue experiment.] Same Side (328ms) cues elicited significantly faster RTs than Neutral cues (337ms, *p* = .043), showing that the cueing effect is one of a general shift to the correct side. For the long SOA, Bonferroni-corrected comparisons revealed a significant difference in RTs following Same Location (294ms) and Same Side (307ms, *p* = .046) cues, but significant differences in RTs between all other Validity conditions (Opposite Side 314ms; Neutral 328ms; all *p*s < .001), suggesting that the cueing effect was location-specific following the long SOA.

5.4 Discussion

The analysis showed no significant effect of AQ group or cue orientation, which suggests that both groups attended to the upright and inverted gaze cues in a similar manner. This does not support our hypotheses of inversion effects in the low scoring groups (cf. Langton & Bruce, 1999) but not in the high scoring groups (cf. Swettenham et al., 2003). Other control groups presented in previous Chapters within this thesis also showed a null effect of orientation. We propose that this effect can be explained by low-level eye gaze direction not being sensitive to inversion when the rest of the face is irrelevant to the task (Kingstone et al., 2000). That is, it is likely that gaze inversion effects are only seen when the whole head/face turns (cf. Langton &

Bruce, 1999) and as such observers are cued by the face as a gestalt, invoking configural processing and thus standard face inversion effects.

The lack of differences between the high and low AQ groups also lends support to the study by Bayliss and Tipper (2005). In their study, they only reported differences between the AQ groups in orienting *towards* social or non-social *targets*. Attentional reorienting in response to centrally presented cues and arrows was equivalent in both groups. Thus we have presented support for the effect found by Bayliss and Tipper (2005), and have shown that this effect is also present in situations of covert orienting in the absence of socially meaningful targets which attract attention in different ways for each group.

In both AQ groups, reorienting responses to gaze cues was shown to be reflexive, as standard cue-validity effects were observed following the short SOA, supporting similar studies in the literature (Driver et al., 1999; Tipples, 2002). However the location-specific cueing effects were not seen until the longer SOA and the reorienting effect was one of a general shift to the correct side of space when SOAs were short. This is consistent with Vuilleumier's (2002) account of attention more generally, where shifts are made rapidly to general areas of interest, with location-specific shifts occurring later. However, this is contrary to the location-specific cueing effects found in older controls in this thesis (see Experiments 4 & 10, in Chapters 3 & 4 respectively), and to those reported by Vuilleumier (2002) in parietal-damaged patients. The lack of location-specific cueing effect following the short SOA appears to be driven by the high scoring AQ group, and may reflect a different cognitive style in this group more generally. That is, analysis of the proportion of anticipatory responses and data removed through cleansing was higher for the high scoring AQ group than the low scoring group, and errors (hits on catch trials) were also more common in this group. This shows on a general level that the high AQ scorers were less attentive than the low scoring group, which could explain the difference in reorienting after a short SOA. This will be returned to in the Main Discussion.

Experiment 14: Upright vs. Inverted Realistic Pointing 'Across the Body' Cues

5.5.1 Materials

The stimuli for this Experiment were the same as those in Experiment 5 (see section 3.*5.1 Materials* in Chapter 3).

5.6 Results

There was no significant main effect of AQ Group (*F* (1, 32) = .001, p = .980), but interestingly there was a main effect of Orientation for the 'across body' pointing cues (*F* (1, 32) = 9.414, p = .004; upright cues 343ms; inverted cues 329ms). There were significant main effects of Validity (*F* (2.1, 68.3) = 81.912, $p < .001$) and SOA (*F* (1, 32) = 79.194, $p < .001$; short SOA 347ms; long SOA 326ms). These effects were qualified by the following interactions: Validity * SOA (*F* (2, 63.2) = 3.925, p = .025) and Orientation * Validity * SOA * Group (*F* (3, 96) = 3.164, p = .028; see Figure 49). Since this higher-order interactions involves all of the experimental factors, it was broken down by first running separate 2 (Orientation: Upright, Inverted) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) within-subjects ANOVAs for each of the AQ groups.

The 2 (Orientation: Upright, Inverted) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) ANOVA for the *low* AQ group revealed significant main effects of Orientation (*F* (1, 16) = 8.686, *p* = .009; upright cues 345ms; inverted cues 327ms), Validity (*F* (3, 48) = 48.048, *p* < .001) and SOA (*F* (1, 16) = 47.639, *p* < .001; short SOA 345ms; long SOA 327ms), and a significant interaction between Validity and SOA (*F* (3, 48) = 9.608, *p* < .001). Bonferroni-corrected comparisons between the Validity conditions at the short SOA showed no evidence of location-specific cueing (Same Location 336ms, Same Side 336ms, *p* > .999) but a general benefit in RTs following Same Side (336ms) cues as compared to Neutral cues (361ms, *p* < .001). However, following the long SOA, Bonferroni-corrected comparisons did reveal location specific cueing-effects, with significant differences in RTs between all Validity conditions (Same Location 307ms, Same Side 322ms, Opposite Side 333ms, Neutral 347ms; all *p*s < .05).

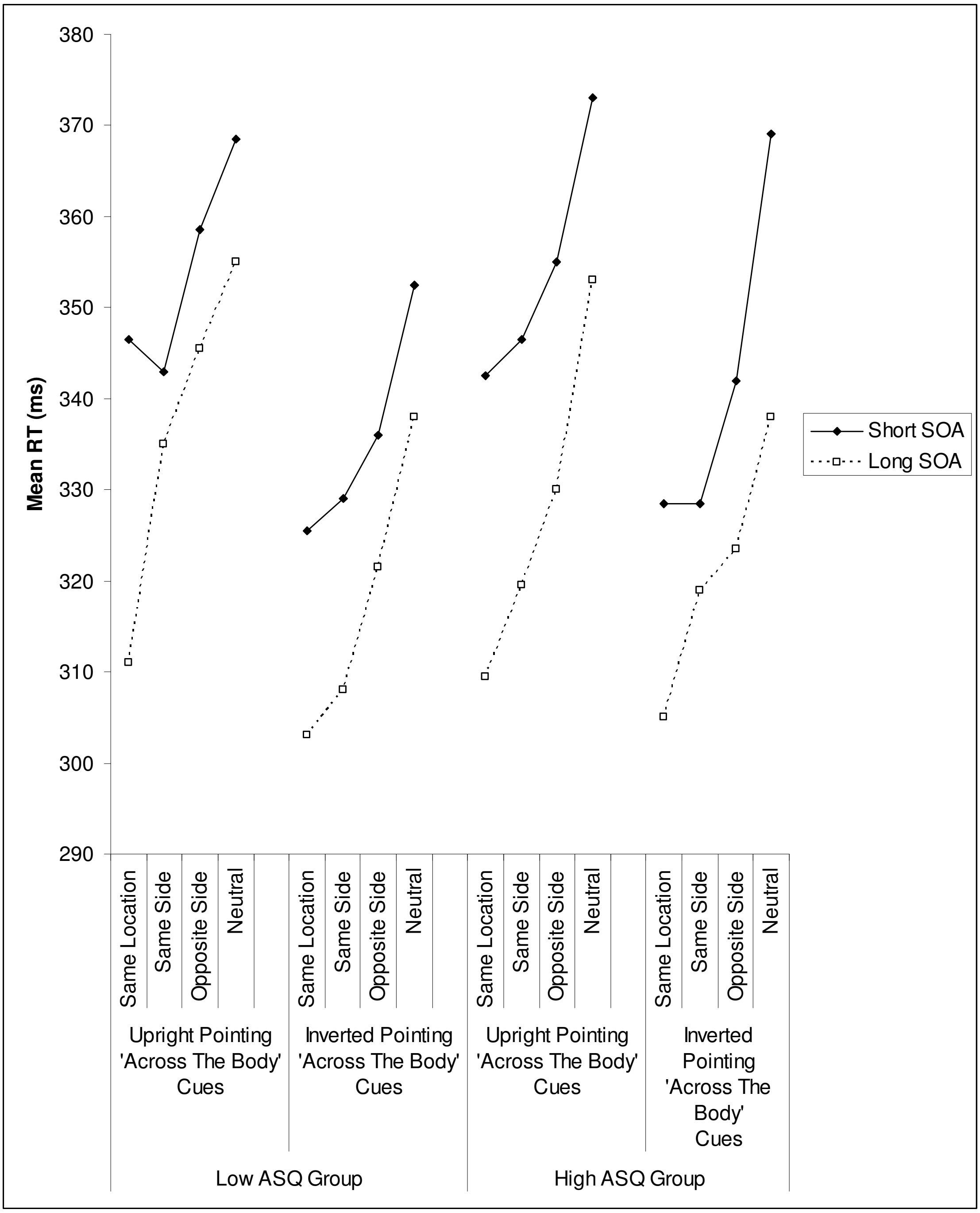

Figure 49. Illustration of the data in all conditions of the upright and inverted pointing 'across the body' cue experiments, for participants in the low and high scoring AQ groups.

The 2 (Orientation: Upright, Inverted) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (Side: Contralesional, Ipsilesional) * 2 (SOA: 100ms, 300ms) ANOVA for the *high* AQ group revealed no significant main effect of Orientation F (1, 16) = 2.051, p = .171, unlike the low AQ group. There were significant main effects of Validity (F (3, 48) = 37.467, p < .001) and SOA (F (1, 16) = 37.174, p < .001; short SOA 348ms; long SOA 324ms), but no higher-order interactions. Bonferroni-corrected comparisons between the validity conditions showed no significant difference between RTs following Same Location (321ms) and Same Side cues (329ms, p = .108) and hence no evidence of location-specific cueing, although differences between all other validity conditions were significant (all *p*s < .005) indicating a general benefit of being cued to the correct side.

5.7 Discussion

The low AQ group showed location-specific cueing across cue orientations following the long SOA, although following the short SOA there was a general shift of attention to the correct hemifield. This is the same as the effect found with gaze cues in the previous experiment with these same participants, and provides further support to our suggestion that pointing gestures are afforded the same social salience and priority of processing as have been suggested of gaze cues (Driver, et al., 1999; Vuilleumier, 2002).

For the high AQ group, the same validity effect was apparent across cue orientations and SOAs, although this was one of a general shift of attention to the correct side, rather than a location-specific benefit. This is the same effect as that reported for control participants in Chapter 3 (Experiment 5), and represents a reflexive, but less precise attentional reorienting than that reported for the low scoring AQ group in response to the pointing cue. The location-specific cueing effects did not emerge at the longer SOA in this group as reported for the same pointing cue in the low scoring AQ group. As reported in the previous experiment with gaze cues, this could be due to differences in the cognitive processing styles between the high and low-scoring AQ groups, where the high scoring group were generally more impulsive with responses (as indicated by hits on catch trials, and anticipatory responses). This explanation will be returned to in the Main Discussion, where performance with all cue types can be evaluated.

Experiment 15: Realistic Pointing Hand Cues

5.8.1 Materials

The stimuli for this Experiment were the same as those in Experiment 6 (see section 3.*8.1 Materials* in Chapter 3).

5.9 Results

The analysis of the pointing hand cues showed no significant effect of AQ group (*F* (1, 32) = .523, *p* = .475). There were significant main effects of Validity (*F* (3, 96) = 102.420, *p* < .001) and SOA (*F* (1, 32) = 19.860, *p* < .001; short SOA 342ms; long SOA 330ms), but no other main effects or interactions approached significance (see Figure 50). Bonferroni-corrected comparisons between the validity conditions showed effects of location specific cueing with a significant advantage in RTs following Same location cues (316ms) over Same Side cues

(326ms, *p* = .012). In addition, all other comparisons between RTs for the validity conditions were significant (all *p*s < .001).

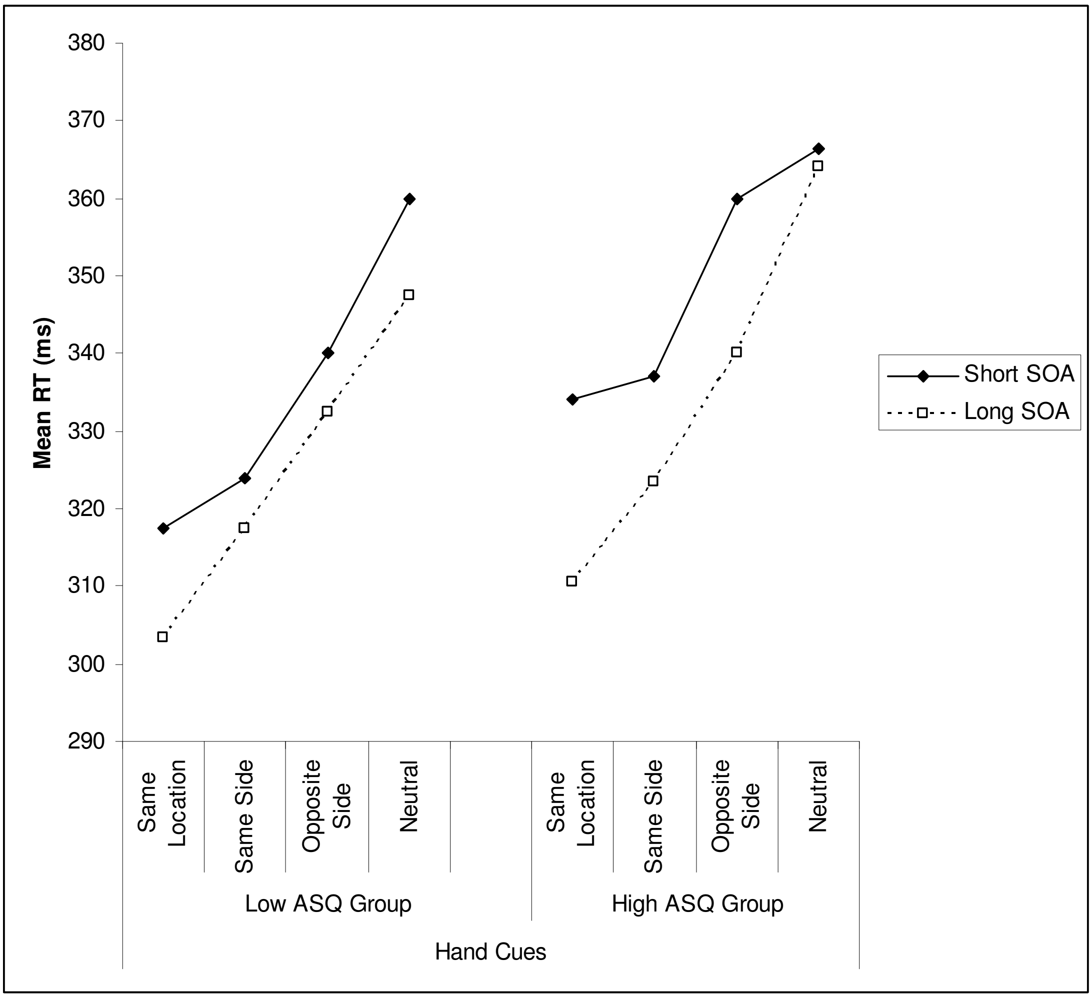

Figure 50. Illustration of the data in all conditions of the pointing hand cue experiment, for participants in the low and high scoring AQ groups.

5.10 Discussion

The analyses showed reliable location-specific cueing effects across the AQ groups and SOAs in response to the pointing hand cue. This effect is indicative of a reflexive and very precise reorienting of attention, which is not influenced by the (potentially) different cognitive processing styles of the high and low scoring AQ individuals. The findings show that orienting in response to the pointing hand cue was better than with either the gaze cue, or the subtle pointing gesture presented in the context of the human body. In this respect, it would seem that the hand cue is processed like a symbolic arrow (Tipples, 2002), devoid of any social meaning to interpret, and thus affords exogenous orienting (cf. Vuilleumier, 2002). This accords with Bayliss and Tipper (2005) who showed that reorienting of attention in response to central arrow cues was consistent across high and low-scoring AQ groups. Nevertheless, cross-experiment analyses between the gaze and different pointing cues will assist us in differentiating the extent of socially relevant and purely directional information portrayed by these cues.

5.11 Cross-Experiment Analyses

To investigate differences in the magnitude of validity effects between the cues, separate analyses were carried out between the types of cues. To find out whether the pointing hand cue elicits the same validity effects as when the pointing cue is presented in the context of a human body, data from the upright outstretched pointing cue experiment was analysed alongside data from the pointing hand cue experiment (see ‘Exploring Effects of Different Pointing Gestures’ below). To explore the potential differences in the validity effects associated with gaze and pointing cues, these were also compared directly in a further analysis. Since the ‘across body’ pointing cue was specifically designed to be closely matched to the gaze cue in terms of motion and cueing properties being contained *within* the central stimulus, data the upright 'across the body pointing' cue experiment was entered into an analysis with the upright gaze cue experiment data (see 'Comparing Validity Effects of Gaze Cues vs. Pointing Cues' below). The results of these cross-experiment analyses will be discussed in the Main Discussion at the end of this Chapter.

Exploring Effects of Different Pointing Gestures

The following analysis was carried out to compare the relative validity effects of the subtle pointing gesture and the pointing hand gesture, and to investigate possible differences in the processing of the pointing cue in the presence of a human body (pointing) and in isolation (hand cue) between the two AQ groups of participants.

A 2 (AQ Group: low, high) * 2 (Point Cue: point, hand cue) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA revealed that there were no significant main effects of AQ Group (*F* (1, 32) = .055, *p* = .815) or Point Cue (*F* (1, 32) = .168, *p* = .685). There were significant main effects of Validity (*F* (3, 96) = 153.184, *p* < .001) and SOA (*F* (1, 32) = 26.692, *p* < .001; short 344ms, long 331ms). Bonferroni-corrected comparisons between the Validity conditions showed location-specific cueing effects across SOAs and Cue Types, with significantly faster RTs following Same Location (317ms) than Same Side (329ms, *p* < .001) cues.

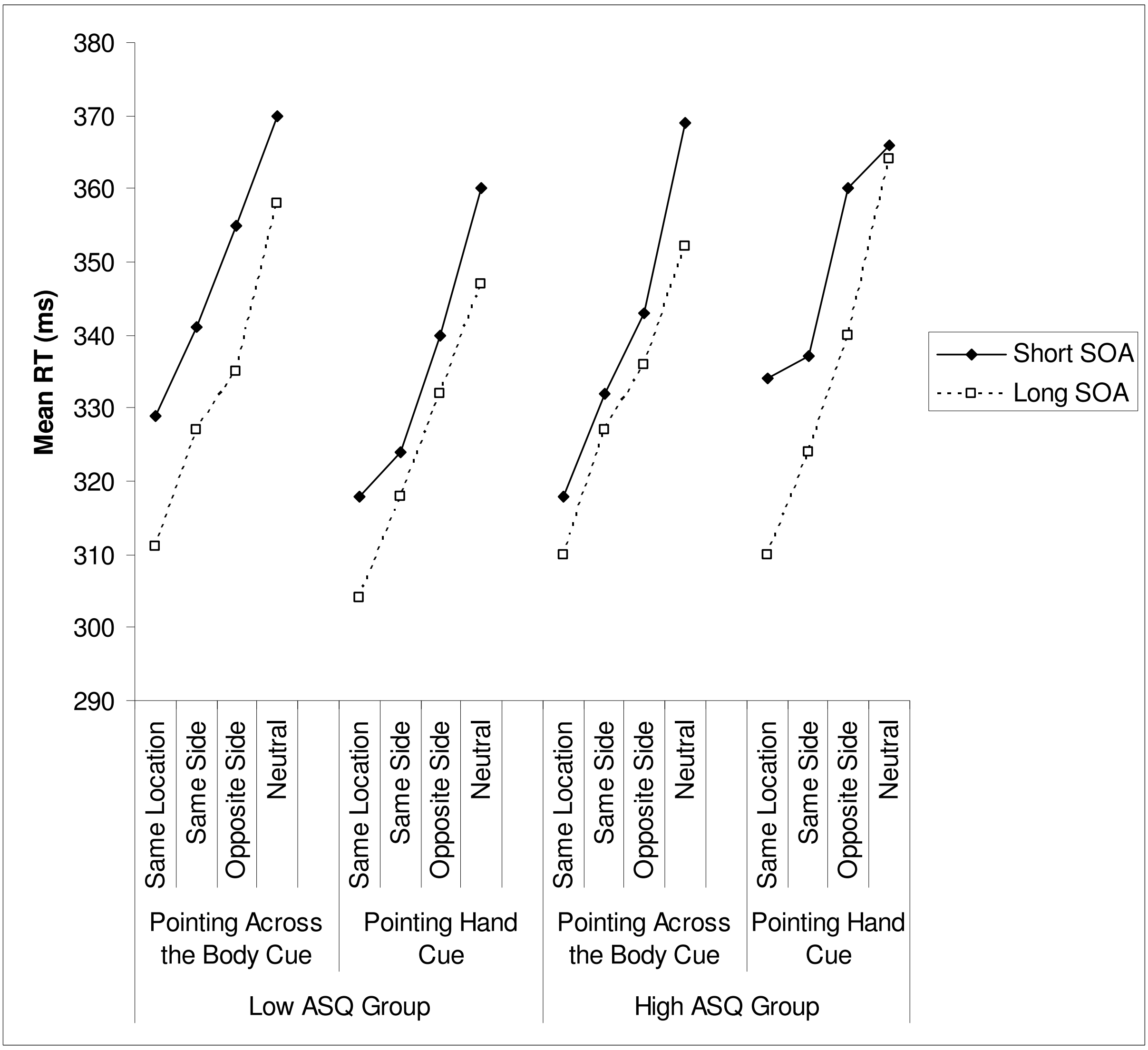

Figure 51. Illustration of the effects of validity and SOA in the pointing cue and pointing hand experiments, across AQ groups

Although there was no main effect of the type of Point Cue presented, this factor did interact with other factors: Point Cue * SOA * Group (*F* (1, 32) = 5.569, *p* = .025; see Figure 51). This three-way interaction was decomposed by running separate 2 (Point Cue: point, hand cue) * 2 (SOA: short, long) ANOVAs for each AQ group. For the *low* AQ group, there was no significant main effect of cue ($p > .100$) but there was a main effect of SOA (F (1, 16) = 19.355, $p < .001$). For the *high* AQ group, there was only a significant main effect of SOA (F (1, 16) = 9.904, p = .006), but no main effect of Cue Type ($p > .500$) and no interaction ($p > .185$). Therefore it would seem that the previous Point Cue * SOA * Group interaction is driven by a stronger effect of SOA in the low group than the high group. Further, although both groups showed no significant effect of the type of pointing cue, the effect of cue also appears to be stronger for the low group than the high group.

Comparing Validity Effects of Gaze Cues vs. Pointing Cues

One of the main purposes of this series of experiments was to investigate the possibility of different processes involved in the orienting of attention following gaze shifts and pointing gestures. The following analysis compares the effects of the upright gaze cues with the upright pointing cue.

A 2 (AQ Group: low, high) * 2 (Cue Type: gaze, pointing) * 4 (Validity: Same Location, Same Side, Opposite Side, Neutral) * 2 (SOA: short, long) mixed-design ANOVA revealed that there was no significant main effect of AQ Group (F (1, 32) = .021, p = .887). There were significant main effects of Cue Type (F (1, 32) = 12.795, p = .001; Gaze 323ms, Point 343ms) and Validity (F (3, 96) = 54.024, $p < .001$), which were qualified by a significant interaction (F (3, 96) = 5.671, p = .001; see Figure 52). Although responses were generally faster in response to gaze cues, there was no location-specific cueing effect of gaze shifts (Same Location: 313ms, Same Side: 320ms; p = .158) however the pointing cues did offer a location specific benefit to RTs (Same Location: 327ms, Same Side: 336ms; p = .042). In addition, there was a significant main effect of SOA (*F* (1, 32) = 94.098, *p* < .001) which interacted with Validity (*F* (2.3, 73.3) = 11.098, *p* < .001). Bonferroni-corrected comparisons revealed that RTs were consistently faster following long SOAs than short SOAs in all validity conditions (all *p*s < .001), and that location-specific cueing effects only occurred after the long SOA (Same Location: 304ms, Same Side: 317ms; *p* = .002) and not following the short SOA (Same Location: 337ms, Same Side: 339ms; *p* > .9; see Figure 52).

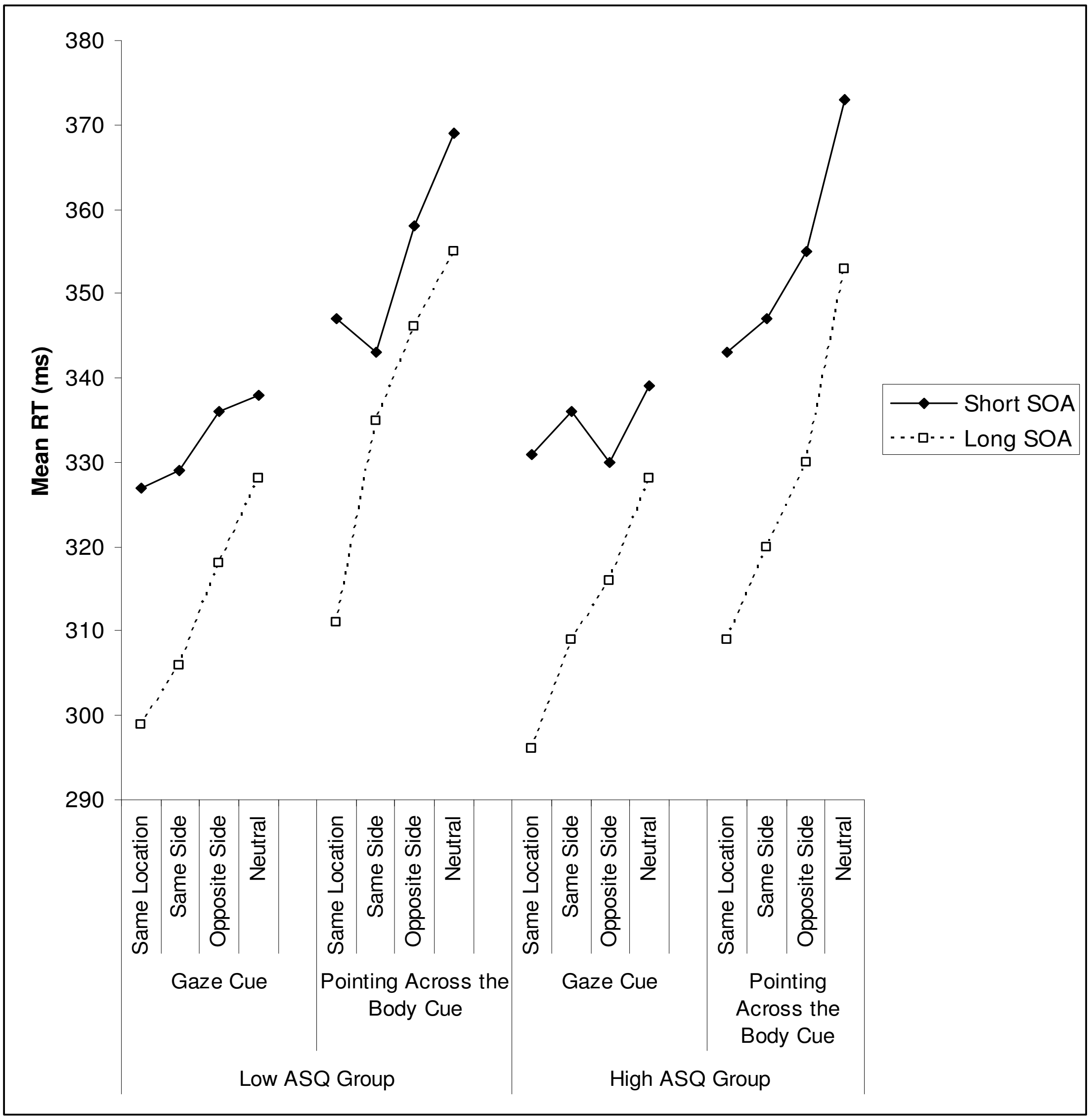

Figure 52. Illustration of the effects of validity and SOA in the gaze cue and pointing across the body cue experiments, across AQ groups.

5.12 Main Discussion

The results were analysed in such a way as to show whether there were differences between the high and low scoring AQ groups, and between the different types of central cue. Generally the analyses showed very little statistical difference between the AQ groups in terms of reorienting in response to the cues, and the resulting target detection. The results of each analysis will be discussed in turn.

Responses to the gaze cues presented in Experiment 13 showed that the validity effects were reflexive, location-specific (but only following a long SOA), were not sensitive to inversion, and were not related to scores on the AQ. Bayliss and Tipper (2005) reported that high and low scoring AQ participants were cued with equal magnitude by central gaze and arrow cues, and so the reported result in this Chapter support this finding to some extent since there was no effect of 'group' upon cue validity. The gaze cueing effect reported here was one of a shift in attention to the general side of target location following the short SOA which is in line with findings of previous studies where the target could appear either on the left or the right of the central cue (Driver et al., 1999). However, this cueing effect only became location-specific following the long SOA, whereas Vuilleumier (2002) reported that parietal-damaged patients and controls could use gaze shifts to reorient their attention to a specific location, even on the neglected side for patients. Indeed, the older controls presented in Chapters 3 and 4 of this thesis could use these realistic gaze cues (Experiments 4 & 7) to reflexively shift their attention to a specific location. It is interesting then, that the participants in this experiment did not display the expected location-specific cueing effect.

The high-scoring AQ group made more anticipatory responses than their low-scoring counterparts, which further suggests that they were not paying adequate attention to the cues, or to the task more generally. However, this may be linked to the different ‘cognitive style’ of the high-scoring group whereby a ‘weak central coherence’ (Happé & Frith, 2006) is underpinned by a bias for local processing. In this sense, the high AQ group may be primed by the movement of the ‘local’ gaze shift (in any direction) and hence find it more difficult to inhibit their response when ultimately no target appears in the ‘global’ scene. This could account for the finding that for the upright gaze cues, the high-scoring group show the same benefit for invalid (‘Opposite Side’) cues as for valid (‘Same Location’) cues. However, this does not explain why the effect does not occur for inverted gaze cues in this group. If anything, face inversion induces a more parts-based processing (Yin, 1969) and as such should exacerbate the effects seen in this group who already favour the processing of local features. The high-scoring AQ group made significantly more hits on catch trials than the low AQ group, indicating a lack of response inhibition as compared to the low-scoring AQ group. These group differences only become apparent in the data analyses of the gaze cues, and not for the pointing cues, which supports the notion that eye gaze following is inherently social in nature (Vuilleumier, 2002) and also that gaze represents a distinct category of stimulus which either cannot be adequately interpreted by ASD individuals (Baron-Cohen, 1995), or induces a different processing style to other socially relevant gestures (Happé & Frith, 2006).

With respect to the subtle pointing cue experiments, there were also slightly different patterns of results for the high and low scoring AQ groups. The low AQ group showed a general effect of being cued to the correct side following the short SOA, which changed to a location-specific cueing effect following the long SOA. However, the high-scoring AQ group showed a general effect of being cued to the correct side which still persisted following the long SOA. Again this is indicative of the high-scoring AQ group not paying adequate attention to the cues in the task, possibly due to a different cognitive style, as discussed. Swettenham et al., (2003) proposed that autistic children are generally slower than typically developing children in preparing and initiating responses generally, independently of social gaze processing. This could explain why reorienting to a specific location was not seen in the high-scoring AQ group, and that perhaps at longer SOA durations this group would be able to orient to precise locations. However, since there were no significant differences in overall reaction times between the two groups we present here, Swettenham et al.'s (2003) explanation does not fully account for the difference in performance between the groups.

Nevertheless, in the absence of the expected difference in cue validity effects between the groups, we can extend our conclusions with greater confidence to the typically developing general population. That is, what is perhaps more pertinent to our research question is the direct comparison of the results from the gaze and pointing experiments, regardless of the null effect of AQ score. This analysis showed that generally eye gaze cues elicited significantly faster RTs than subtle pointing across the body cues. As borne out in the individual analyses, both cues elicited reflexive orienting responses, but location-specific cueing only occurred following the long SOA. Here the slightly different cueing effects produced by each of the AQ groups in the pointing cue condition were averaged out to produce a similar cueing effect of upright gaze shifts and subtle pointing cues. This is the same results as reported with older control groups in Chapter 3 (Experiment 5), and thus shows that not only was there no difference in cue-validity effects between the AQ groups, but that their performance was comparable to an independent group neurologically intact older controls. This adds reliability to our postulation that pointing cues can elicit similar shifts of covert attention as gaze cues, and also adds support to Langton and Bruce's (2000) findings of independent interference effects of to-be-ignored cues on attended cues. That is, we have shown that both gaze and pointing cues exert a strong and unavoidable influence on covert attention in normal observers, even in the absence of instruction to respond to directionality of one of the cues. When the different pointing cues (subtle pointing cue in the context of the body or the pointing hand in isolation) are compared in the same analysis there is no evidence of different validity effects for each type of pointing cue. As we suggested in the discussion of the results from the hand cue experiment, it is not necessary for the pointing gesture to be presented in the way it would be encountered in real life (i.e. in the context of the rest of the body) for the location-specific cueing effects to take place. Logically then, we can also conclude that there is also no difference between the relative cueing effects of the gaze and pointing hand cues. As we have shown evidence, at least in this group of participants, that gaze cues elicit significantly faster responses than do pointing cues, we do not rule out the existence of a ‘special’ or ‘unique’ mechanism for gaze processing within the neural network. Rather more modestly, we have shown that other human socially relevant gestures can also serve to reflexively shift attention covertly to discrete locations within the immediate environment. This will be discussed relative to the findings from our other neuropsychological and typically developing participants in the General Discussion for the thesis.

CHAPTER 6:

GENERAL DISCUSSION

The experiments in this thesis were carried out with the aims of investigating the relative cueing effects of different types of social and symbolic cues (gaze, pointing and arrows). A review of the social cognition and neuropsychological literature revealed a paucity of research into attentional reorienting in response to pointing gestures, relative to such research on gaze cues. The gaze cueing literature has tended to compare the effects of gaze with those of symbolic arrow cues, in order to establish the degree of reflexivity of attentional reorienting in response to each of these cues, with many researchers claiming that gaze holds a 'unique' social salience. The research presented in this thesis thus explored the cueing effects of human pointing gestures, and we proposed that this stimulus could be seen as 'bridging the gap' between eye gaze and arrow cues. That is, pointing represents another cue to direct another person's attention, which is human in nature but distinct from eye gaze. We assessed the relative validity effects of gaze shifts, pointing gestures and symbolic arrow cues in order to establish how attention is reoriented in response to each of the cues. Furthermore, we assessed these relative cueing effects in three distinct populations in order to gain a broader understanding of the cognitive mechanisms which underpin the processing of, and orienting to, each of these cues. Firstly, we investigated the cueing effects of schematic (Chapter 2) and realistic (Chapter 3) social and symbolic cues in a group of parietal damaged patients who presented with visual extinction, to establish whether pointing cues could indeed cue attention to the impaired hemifield in the same way as has been shown for gaze cues (Vuilleumier, 2002). Next, we carried out our investigations in a parietal damaged patient who presented with an acquired theory of mind deficit. This series of experiments provided us with a means of establishing whether accurate attentional reorienting in response to pointing gestures required the attribution of a mental state to the 'pointer', in a similar way to gaze (i.e. via the SAM; Baron-Cohen, 1995). We hypothesised that if joint attention is required in order for pointing cues to be effective in shifting covert attention, as is the case for eye gaze, then a patient with a theory of mind deficit would not be able to make use of either the gaze or the pointing cues. Although this would provide support for a strong link between SAM and ToM (Baron-Cohen, 1995), the causality between the spared and impaired modules would still be open to question. These experiments thus allowed us to assess whether gaze is indeed unique in its 'social' relevance to reflexive attention shifts. Finally, the cueing effects of the gaze and pointing stimuli were explored in a group of typically developed adults who display a high proportion of autistic personality traits. From these studies we could investigate the prevalence of individual differences in the use of gaze and pointing cues the general population (as a function of AQ score), and thus draw inferences about how these cues might be used in autistic individuals. An outline of the main findings from each of these lines of study will be presented in turn, evaluating the relative effectiveness of the gaze and pointing cues in each group of participants. Then a cross examination of the participant groups will inform us of the attentional mechanisms which underpin the processing and attentional to each type of cue.

6.1 Parietal Damaged Patients

The studies in this thesis were based upon the empirical findings of Vuilleumier (2002), who showed that eye gaze shifts could cue patients with hemispatial neglect to specific locations on their contralesional side on the other hand. Vuilleumier (2002) found no such effect when a symbolic arrow was used to cue attention and thus concluded that gaze cues are unique in their reflexive, location-specific validity effects. Chapter 2 set out with the aim to replicate and validate the findings of Vuilleumier (2002), and to extend this investigation to the cueing effects of schematic pointing gestures. Specifically, we wanted to know whether all schematic 'social' cues are influential in reorienting the attention of parietal-damaged patients, or is eye gaze really 'special'.

The results from Experiment 1 partially support those of Vuilleumier (2002), where gaze shifts were successful in inducing reflexive orienting to targets appearing on the patients' contralesional side. In addition to the reflexivity of this response, we also found location-specific cueing effects to patients' ipsilesional side, and also to both sides in a group of neurologically intact controls. This effect was replicated with more realistic photographic face/gaze cues (Experiment 4) in a larger group of parietal-damaged patients, thus adding support to the reliability of our findings. To this end, we replicated the results of Vuilleumier (2002) and validated the effectiveness of his experimental paradigm for use in our subsequent investigations. However, we were unable to replicate the location-specific cueing effects found by Vuilleumier (2002), as our group of patients did not show location-specific cueing effects to the contralesional side. Furthermore, when realistic face images were inverted (Experiment 4) there was no evidence of cue validity to ipsilesional or contralesional sides in our patient group. We propose that these discrepancies are due to differences in the aetiology of impairments between the patient group presented here, and those studied by Vuilleumier (2002). Hemispatial neglect is characterised by impairments in spontaneous exploration of the environment on the contralesional side of space, whereas visual extinction is characterised by an inattention to contralesional stimuli only when in the presence of a stimulus competition (i.e. a simultaneous ipsilesional stimulus). Karnath et al. (2001, 2003) have linked hemispatial neglect with lesions to the STG, and visual extinction to lesions of the TPJ. However, the TPJ is also implicated in gaze following (Saxe & Kanwisher, 2003). It is beyond the scope of the current research to speculate on spared and impaired cognitive mechanisms in relation to the lesions in our patient group. Rather we suggest that our patients could use intact brain areas (STS and, to some extent, TPJ) to extract meaning from canonical gaze cues and shift attention accordingly, but that residual damage to the TPJ impairs gaze following when faces are inverted, and impairs orienting to precise locations on the extinguished side, and causes a breakdown in gaze following when the face is inverted.

Experiment 2 showed the same pattern of cueing effects was found in response to symbolic pointing cues across the contralesional (general shift to side) and ipsilesional (location-specific shifts) sides in the same patient group. Experiment 3 showed that orienting in response to arrows produced no such location-specific effects, and that regardless of target side, attentional reorienting was one of a general shift to the correct side. Therefore, pointing gestures served to cue attention more precisely than arrow cues, and in a remarkably similar manner to that found with gaze cues. Further investigations (Experiments 5 and 6) showed that it made no difference whether the hand is presented in the context of the rest of the body for the cueing effects to occur in response to pointing gestures. Importantly, statistical analyses showed there were no interactions between the cue type, cue validity and group factors, which showed that patients and controls produced similar validity effects across the different types of pointing cues and gaze cues. This supports the notion of pointing cues being social rather than symbolic in nature, and thus being as able as gaze cues to direct our attention to specific locations in the environment. That is not to say that location-specific cueing is cueing is ‘unique’ to socially relevant stimuli, but rather that there may be an evolutionary relevance to these types of 'social' cues. That is, gaze or pointing cues can not only warn of danger or sources of potential threat (which would benefit from highly efficient orienting to prepare an appropriate response) but can also elicit more accurate joint attention to facilitate appropriate social interactions, such as enabling us to understand exactly who a person is talking about (or to) simply by their direction of gaze. The cueing effect of the pointing gesture is not lost when the hand is presented in isolation, rather than as part of the body which suggests that the gesture is processed independently of the rest of the body (cf. Reed et al., 2003). This is not to say that the pointing cue is any less 'social' in nature than eye gaze cues, but that they may be processed in a parts-based way to allow for the extraction of and attention to relevant gestures. Overall the findings imply that gaze is not unique in its ability to orient attention reflexively and accurately in normal observers, which supports previous experiments when gaze cueing is compared to that of arrows (e.g. Tipples, 2002).

To our knowledge, this is the first line of evidence that gaze *and* pointing cues can induce reflexive 'social' orienting in parietal damaged patients. As such, this implies a role for the TPJ in the processing of pointing cues, but whether pointing gestures require similar extraction of meaning as gaze cues (i.e. via 'social' orienting and joint attention), or whether they guide attention in a purely directional manner was assessed in the Chapter 4 with a patient displaying a theory of mind deficit.

6.2 Acquired Theory of Mind Deficit

We investigated the relative cueing effects of our gaze and pointing cues in a patient with an acquired theory of mind deficit. We proposed that since this patient cannot infer the mental states of others that are required for gaze following (Baron-Cohen, 1995), we can contrast his performance in each of the experiments to establish whether the pointing cue requires social meaning to be extracted, or if it is purely directional in nature. We confirmed his impairment in gaze-following in Experiments 7 and 10, where he showed no reliable cueing effects in response to schematic or realistic gaze cues. Experiment 9 confirmed that this was a specific impairment to gaze following, since the patient was reliably cued to both contralesional and ipsilesional sides by a symbolic arrow cue. However, importantly for our investigations, was the finding that patient RH could orient his attention to specific locations in response to a simple pointing gesture. The effect was lost when the pointing cue was inverted and so could not be explained by simple motion cues or purely directional cues as portrayed by arrows. Indeed RH's following of upright pointing cues was more precise than his orienting to purely directional arrows. We suggest therefore that a pointing gesture is a more salient cue than a symbolic arrow due to its social relevance, and thus that RH can use socially meaningful information other than eye gaze (i.e. pointing gestures), to direct his attention accurately to specific locations in the environment. In terms of Baron-Cohen's (1995) model, this suggests that although patient RH may have impairments to the both the EDD and ToM modules, the SAM appears to be intact. However, this cannot tell us whether the impaired EDD causes the break-down of ToM, or whether a ToM deficit leads to an impaired EDD. Both accounts of causality are at least equally plausible, although further speculation of directionality is beyond the scope of this thesis.

For patient RH, the observed validity effects across the different pointing cues suggests that when presented alone, the pointing hand cue is not associated with the human body (or at least, not attributed a mental state) and thus serves to reorient attention normally in RH. However, the hand cue afforded a location specific cueing effect in RH, whereas the symbolic arrow cue only served a general shift of attention to the correct versus incorrect side more generally. Since RH could use the hand cue to overcome his spatial orienting deficit, but could not do the same for the subtle pointing cue in the context of the body, we propose that the latter ‘body’ cue must hold some social relevance that cannot be decoded by RH due to his ToM deficit. This dissociation provides further support for our suggestion that human pointing cues do hold some salience with regards to their social nature, and can reorient attention reflexively to specific locations in normal observers, as well as improve attentional reorienting relative to symbolic arrow cueing even in the presence of a theory of mind deficit. Thus, we provide support for the notion that ToM deficits are related specifically to impairments to gaze following (cf. Baron-Cohen, 1995), rather than to social orienting more generally. However, there is widely observed debate over the appropriate statistical analyses for single-case data (see Main Discussion in Chapter 4: Part II for details) and although steps were taken to reduce the chance of a Type I error, the nature of the experiment and number of conditions precluded alternative analysis techniques (e.g. nonparametric tests). Therefore, although we have demonstrated that patient RH shows a deficit in attentional reorienting in response to eye gaze, this effect may be exaggerated by the statistical analyses employed. Further research could employ a simpler experimental design with fewer factors to compare the cueing effects of gaze and pointing cues, where appropriate nonparametric analyses can be applied.

6.3 Autistic Personality Traits

Research has shown that autistic spectrum disorders lie along a continuum, and as a result autistic type ‘traits’ are found in the normal population (Stewart et al., 2009). Baron-Cohen et al. (2001) developed a now well-established and reliable tool (AQ) for assessing the extent of these traits displayed by typically developed adults. This has provided an incredibly useful way of assessing cognitive processing styles akin to ASD, without the confounding influence of language and IQ deficits present in such ASD samples. Bayliss and Tipper (2005) showed similarities in social orienting mechanisms between autistic individuals and those who display autistic 'traits' as assessed by the AQ. Further to our studies with a theory of mind patient, we explored the relative cueing effects of gaze shifts and pointing gestures with a group of adults who show a higher than average proportion of autistic personality traits, to further examine the extent to which pointing cues can reorient covert attention in autism.

Comparisons between the realistic gaze and subtle pointing experiments showed that generally eye gaze cues elicited significantly faster RTs than subtle pointing across the body cues. However, we found a similar cueing effect of upright gaze shifts and subtle pointing cues, where both cues elicited reflexive orienting responses to the correct side of space, with location-specific cueing effects occurring later. This is similar to the pattern of results we found in the group of older controls presented in Chapter 3, showing that the performance of our sample of participants who scored high or low AQ groups, was comparable to an independent group neurologically intact older controls. We propose that this adds reliability to our postulation that pointing cues can elicit similar shifts of covert attention as gaze cues, and also adds support to Langton and Bruce's (2000) findings of independent interference effects of pointing cues on gaze cues, and vice versa (see section *1.2 Social Cues and Normal Attention* in Literature Review for details). We did discover subtle differences in how our target detection tasks were attended between these two groups. For example, the high scoring group responded incorrectly to catch trials, and made rapid anticipatory responses to a higher proportion than the low scoring group. This effect can be accounted for by the 'weak central coherence' theory (Happé & Frith, 2006) and of different cognitive styles inherent in ASD than in typically developing individuals. That is, we proposed that individuals who show a high proportion of autistic traits will also share elements of this cognitive style which favours local over global processing. As we showed subtle differences between the high and low scoring AQ groups, we provide support for the notion that ASD traits are continuous throughout the normal population, but also demonstrate that the differences in cognitive style may be minimal and only borne out on more cognitively demanding tasks (Stewart et al., 2009). Ultimately, our results showed few overall differences in performance between participants who display a high proportion of autistic traits, and those who show a very low proportion of these traits. It is therefore possible for us to extend our conclusions with greater confidence to the typically developing general population, and adds reliability to the similar results we found with smaller samples of older control subjects. That is, we have shown that both gaze and pointing cues exert a strong and unavoidable influence on covert attention in normal observers, even in the absence of instruction to respond to directionality of one of the cues. However, we have shown that, at least in this group of participants, that gaze cues elicit significantly faster responses than do pointing cues, we do not rule out the existence of a 'special' or 'unique' mechanism for gaze processing within the neural network. Rather more modestly, we have shown that other human socially relevant gestures (i.e. pointing) can also serve to reflexively shift attention covertly to discrete locations within the immediate environment.

6.4 Cross-Group Comparisons

Our results show very similar effects of reflexive orienting in response to gaze and pointing cues across our older control groups, participants displaying a high or low proportion of autistic traits, and patients with parietal damage. This suggests that pointing gestures are as efficient and successful as gaze shifts at directing our attention to specific locations in the environment. The cueing effect of the pointing gesture is not lost when the hand is presented in isolation, rather than as part of the body which suggests that the gesture is processed independently of the rest of the body (cf. Reed et al., 2003). Across these groups, the findings imply that gaze is not unique in its ability to orient attention reflexively and accurately, which supports previous experiments when gaze cueing is compared to that of arrows (e.g. Tipples, 2002). Further to this finding, our results show that this reflexive and accurate orienting response also occurs in response to human pointing cues, despite cue direction being non-predictive to target location and participants being told to ignore the cues. With regards to the mechanisms underlying this reflexive attentional reorienting, Vecera and Rizzo (2004) have argued that similar validity effects can be achieved by gaze shifts and arrows through over-learned associations between the direction of the cue, and interesting stimuli appearing at the cued locations. This also provides an explanation for our reflexive orienting response to pointing cues, that is, it is achieved via an over-learned association between the direction of someone else's pointing gesture and an area of potential interest in the environment.

Although we have presented very similar findings of reflexive orienting in response to both gaze shifts *and* pointing gestures in parietal damaged patients, older controls and autistic-type normal participants, our results were very different in our patient with an acquired theory of mind deficit. We showed that this patient could not use eye gaze shifts to reorient his attention to the cued hemifield, regardless of whether the gaze cues were schematic or realistic. Conversely, we showed that he could orient his attention reflexively and to specific locations in response to a hand cue in isolation, which was more precise than his orienting to purely directional arrows (which was general to one side). However, when we presented RH with a subtle pointing gesture in the context of the rest of the body (Experiment 14) there was no reliable cueing effect, which mirrors his performance with eye gaze cues. Since this patient could use the hand cue to orient attention, but not when it was in the context of the body, we propose that the 'body' cue must hold some social relevance that cannot be decoded by RH due to his theory of mind deficit. That is, RH is able to process directional information from pointing hand cues, but this ability is lost when the hand is presented in the more socially relevant context of the human body. This adds weight to our claim that human pointing cues do hold some salience with regards to their social nature, and that an intact theory of mind is required in order to extract meaning from the pointing gestures and engage joint attention mechanisms. Thus, we demonstrate that acquired ToM deficits are modulated by impairments to social orienting more generally rather than specific abnormalities in gaze following (cf. Baron-Cohen, 1995).

6.5 Conclusions and Future Directions

Overall, we have presented evidence that parietal damaged patients and controls show largely the attentional reorienting effects in response to eye gaze shifts, human pointing gestures and symbolic arrows. Further to this, a case study of a patient with an acquired theory of mind deficit showed that he was unable to use gaze or pointing cues which were presented in the context of the human body. Thus we propose that this demonstrates evidence to support that, like understanding of gaze direction, pointing too requires joint attention via mental-state attribution to the 'pointer'. However, we have also highlighted the limitations of drawing strong inferences from a single-case study, and suggest that although we have taken steps to minimise a Type I error the effect observed in our patient RH may be exaggerated in relation to the control group. However overall, the results support that gaze, symbolic arrows, and now pointing cues are similar in that they all afford reflexive orienting in normal observers (Tipples, 2002), but this is probably due to over-learned associations across development (Vecera & Rizzo, 2004). However, when joint attention mechanisms are impaired via an acquired theory of mind deficit, the cueing effect of gaze and pointing cues disappears but orienting in response to purely directional cues is still intact. This cannot be due to patient RH simply failing on tasks which measure weak effects (i.e. gaze-cueing tasks), since our arrow cueing experiment also yielded relatively weak cueing effects in controls, yet patient RH still showed significant cue validity effects in this task. Future research should focus on further delineating different mechanisms underlying spatial orienting deficits (as demonstrated in our extinction patients and RH) from those underlying social orienting deficits (as demonstrated in RH only). We have shown to some extent how these can be dissociated in patient RH who shows neglect and a theory of mind deficit, but as the TPJ is implicated in both of these disorders, more sophisticated imaging or lesion analysis techniques may be necessary help us to understand the neural networks which are responsible for each.

For now, we have shown that pointing gestures are as socially relevant as gaze shifts, at least in normal observers, and that pointing gestures are strong enough to overcome spatial orienting deficits in parietal damage. Thus we propose that eye gaze is not ‘unique’ in its ability to cue attention to areas of interest within the environment (cf. Vuilleumier, 2002), but that human pointing gestures also afford this ability and that the two cues must be underpinned by the same social orienting mechanism. This finding could be incorporated into rehabilitation strategies for hemispatial neglect. Typical interventions for the attenuation of visual neglect in rehabilitation settings tends to be in the form of cueing the patient to the neglected side of an object (e.g. a plate of food, a clock) by means of a red sticker on the neglected side of the item

(M. J. Riddoch, *personal communication*). However, this research shows that perhaps a smiley face or even pointing hand diagram could be a better cue to shift the patients' attention to the neglected side of objects or space.

Future research with brain imaging or lesion analysis techniques can inform how these two cues are represented in neural networks for social communication (Haxby et al., 2000) and the subsequent interplay with spatial attention networks. Furthermore, future laboratory experiments could incorporate gaze and pointing cues into other paradigms which investigate the allocation of attention to visual scenes, e.g. visual search or attentional blink. From these experimental procedures it would be possible to explore how attention is captured by gaze and pointing cues in the context of a more visually complex scene. That is, is one cue more salient at capturing and or reorienting attention than another, and if so is this modulated by the social context of the scene? Answering these questions would aid our understanding of the interplay between social and spatial orienting, not only in cases of neuropsychological impairments, but also in everyday visual explorations and interactions within social situations.

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APPENDIX I:

THE NEURO-ANATOMY OF NEGLECT AND EXTINCTION

Neglect and extinction normally occur following a stroke, which happens as a result of a haemorrhage or a restriction of the blood flow in the brain. In the past, neglect has most frequently been associated with damage to the inferior parietal lobule (e.g. Vallar & Perani, 1986), although more recent research has used high resolution MRI (magnetic resonance imaging) to dispute the accuracy of this claim. Mort, Malhotra, Mannan, Rorden, Pambakian et al. (2003) divided 35 patients into two groups, depending on the location of their stroke; middle cerebral artery (MCA) or posterior cerebral artery (PCA). The patients who displayed hemispatial neglect were then compared to those who did not, but who had the same stroke location. Mort et al. (2003) discovered that for the MCA territory group, the critical location shared by all neglect patients was the angular gyrus of the inferior parietal lobule (IPL; see also Vallar & Perani, 1986). Karnath, Ferber & Himmelbach (2001) had previously claimed that neglect occurs following damage to the temporal lobe, rather than the parietal lobe. Karnath et al. (2001) specifically implicated damage to the superior temporal gyrus (STG) in hemispatial neglect, although only half of Mort et al.'s (2003) MCA neglect patients had damage to the STG. Mort et al. (2003) concluded that the STG was not a critical lesion location in neglect, both through comparison of neglect and non-neglect patients, and through individual analyses of regions of interest. Furthermore, Mort et al. (2003) found that in PCA-territory neglect patients, the parahippocampal region of the medial temporal lobe was critical. These findings further specify the involvement of damage to posterior parietal areas in neglect, but also implicate more explicit areas (i.e. angular gyrus), including temporal regions (i.e. parahippocampal area), in this phenomenon.

A separate line of research has explored the anatomical correlates of visual extinction, and it has been argued that these areas dissociate from those implicated in neglect. Karnath, Himmelbach & Küker (2003) attempted to establish the critical areas of cortical involvement in visual extinction, by using a similar methodology to that of Mort et al. (2003). Seven patients with neglect but no extinction, and 4 patients with extinction but no neglect, and 7 right-hemisphere damaged patients without neglect or extinction were recruited. Consistent with their previous findings (Karnath et al., 2001) Karnath et al. (2003) reported a central lesion overlap in the middle part of the STG in the seven neglect patients, with lesions extending to ventral parts of the pre-and post-central gyri. This finding contradicts that of Mort et al. (2003) although this discrepancy may be a product of the different methodologies used by the two different groups of researchers (see below).

The lesion in Karnath et al.'s (2003) four extinction patients overlapped mainly at the temporo-parietal junction (TPJ), and extended to caudal areas of the STG and middle temporal gyrus (MTG), and to the ventral IPL. Since pure extinction is relatively rare, Karnath et al. (2003) subtracted the lesions of the pure neglect group (n = 7) from the lesion overlap of a group with neglect and extinction (n = 16) to identify the areas associated with extinction in these patients. The remaining lesion overlap corresponded with the area identified in the group of four 'pure extinction' patients. That is, the areas associated strongly with extinction were the TPJ, caudal areas of the STG and MTG, and the ventral area of the IPL. A statistical analysis of the percentage of damage to each of these areas of interest showed a significantly greater involvement of the TPJ in the neglect and extinction group than in the pure neglect group, and no difference in the extent of the damage to the STG between the two groups.

Although previous researchers had suggested that the TPJ was heavily associated with *neglect* (e.g. Corbetta & Shulman, 2002), Karnath et al. (2003) explain their findings in terms of the involvement of the TPJ in the detection of salient stimuli and changes in the environment; processes which seem to be impaired in visual extinction. Furthermore, they argue that neglect is associated with the STG because this structure is strongly implicated in spontaneous exploration of the environment in normal observers (Karnath et al., 2001). These findings imply that there are anatomically dissociable areas for exogenous and endogenous processes.

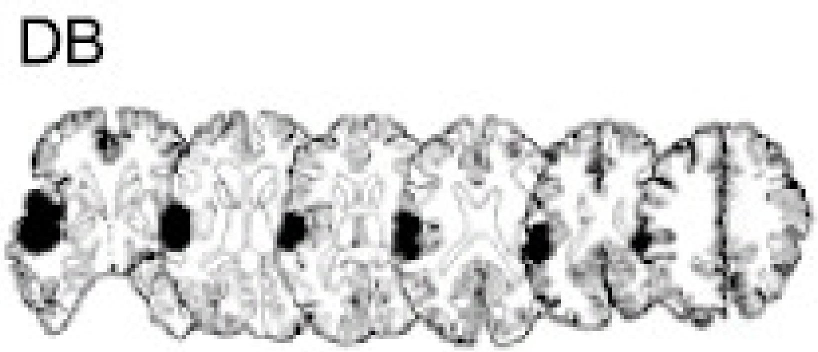
Karnath et al. (2003) have thus suggested that neglect and extinction are anatomically and functionally dissociable. Owing the anatomical proximity of the cortical structures involved in hemispatial neglect and visual extinction, it is not surprising that these two impairments are often found in combination. Furthermore, these structures are close to the MCA territory, offering an explanation for why neglect and extinction commonly occur following a stroke.

The differential findings of Karnath et al. (2003) and Mort et al. (2003) regarding the critical lesion locations in neglect may be due to differences in lesion-mapping methodologies. Mort et al. (2003) used high resolution MRI scans, divided patients into groups depending stroke site and presence of neglect, extinction, both or none, traced around the lesion directly on the digital image as a 2D region of interest at the voxel level, and then combined them to form a 3D lesion for each patient, and finally normalised each MRI scan, including the lesion, onto the standard template in SPM99 (www.fil.ion.ucl.ac.uk/spm). Karnath et al. (2001; 2003) used a combination of MRI and CT scans, did not discriminate original stroke locations (i.e. MCA or PCA), and lesions were drawn manually onto the template MNI brain (Montreal Neurological Institute, www.bic.mni.mcgill.ca). The different methods of scanning, tracing the lesions and the normalisation processes used by Mort et al. (2003) and Karnath et al. (2001; 2003) are likely to contribute to the overall differences in lesion overlap location for the neglect patients. The methods used by Mort et al. (2003) were more technologically advanced, less observer-dependant, and hence more spatially accurate than the methods of Karnath et al. (2001; 2003). In this sense, Karnath et al.'s (2003) assertion of the vital cortical areas in visual extinction may be inaccurate. More recently, Hillis, Chang, Heidler-Gary, Newhart, Kleinman, et al. (2006) have reported that visual extinction is associated with damage to the visual association cortex, which corresponds to the posterior parietal lobe. Although the TPJ is within the area of visual association cortex (or posterior parietal lobe), Hillis et al. (2006) do not report specific areas within the posterior parietal cortex, or any temporal areas, which would specifically support the findings of Karnath et al. (2003). Unfortunately, the spatial smoothing and normalisation process will make any neuroimaging studies liable to anatomical inaccuracies, and it is regrettable that this has such significant effect upon our knowledge of the structure of the human visual attention system, and the neural basis of visual extinction.

APPENDIX II:

NEUROPSYCHOLOGICAL PROFILES

<u>*DB*</u>



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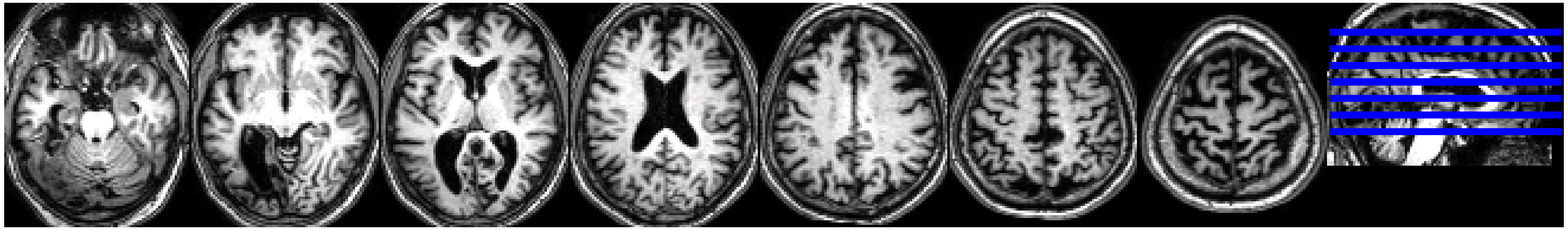

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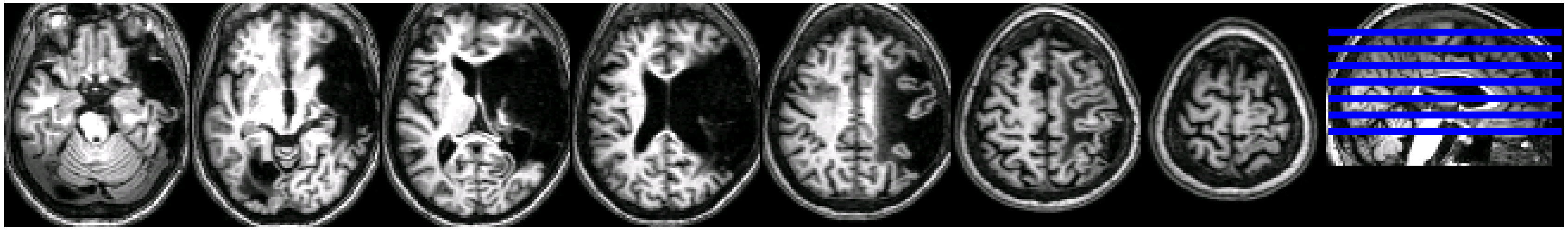

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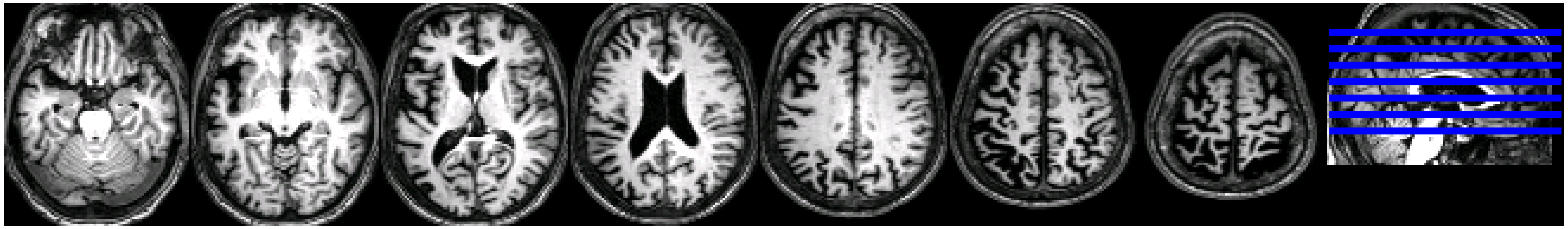

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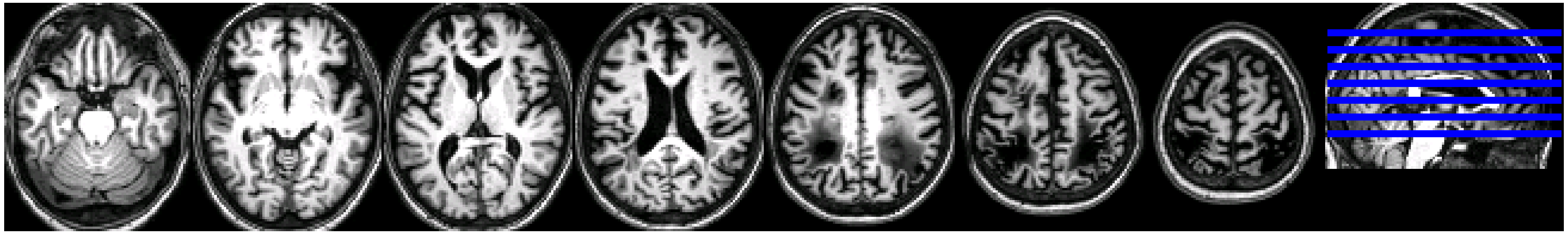
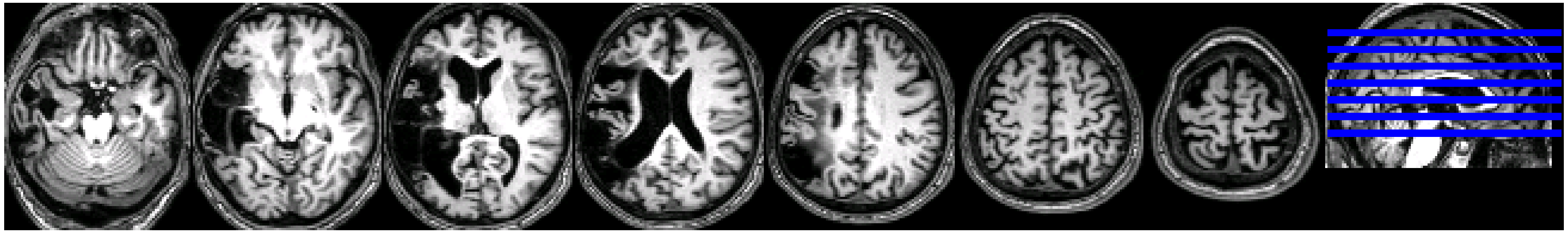


RH



RP

List of the patients tested, lesion site and clinical details. IPL, inferior parietal lobe; SPL, superior parietal lobe; SMg, supramarginal gyrus; ANg, angular gyrus; ITg, inferior temporal gyrus; MTg, middle temporal gyrus; STg, superior temporal gyrus; IFg, inferior frontal gyrus; MTg, middle temporal gyrus; SFg, superior frontal gyrus.

Patient	**Sex**	**Age**	**Laterality**	**Aetiology**	**Lesion**	**Clinical deficit**
DB	M	75	Right	Stroke	**Left** inferior parietal (ANg), temporal (STg, MTg)	Right extinction Aphasia
DT	M	69	Right	Stroke	**Left** parietal cortex	Right extinction
JB	F	75	Left	Stroke	**Left** inferior occipital, lingual and parahippocampal gyrus **Right** parietal (ANg and SMg, IPL), temporal (ITg, MTg, STg), and frontal (IFg,MFg) cortex	Left extinction Left neglect (in reading and writing)
MH	M	57	Right	Anoxia	Bilateral lentiform nucleus Bilateral subcortical damage **Left** parietal (SMg, ANg, IPL, SPL), temporal (MTg, STg) and frontal cortex (IFg, MFg, SFg) **Right** parietal (SPL) and frontal cortex (SFg)	Right extinction Optic ataxia
PF	F	62	Right	Stroke	**Left** parietal cortex (IPL, SPL) **Right** parietal cortex (ANg, IPL, SPL)	Left extinction Dysgraphia Mild simultanagnosia
RH	M	77	Left	Stroke	**Left** parietal (ANg, SMg, IPL), temporal (STg, MTg) and frontal (IFg, MFg) cortex	Right object-based neglect (in reading) Right extinction Deep dysphasia, dyslexia, dysgraphia
RP	M	56	Right	Stroke	**Right** parietal cortex	Left neglect Left extinction

APPENDIX III:

AUTISM-SPECTRUM QUOTIENT

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J. & Clubley, E. (2001)

The Autism-Spectrum Quotient (AQ): Evidence from Asperger syndrome / high-functioning autism, males and females, scientists and mathematicians.

Journal of Autism and Developmental Disorders, 31, 5-17.

Question	*Response (Please circle)*			
1. I prefer to do things with others rather than on my own	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information	definitely agree	slightly agree	slightly disagree	definitely disagree
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy	definitely agree	slightly agree	slightly disagree	definitely disagree

12. I tend to notice details that others do not	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy	definitely agree	slightly agree	slightly disagree	definitely disagree
15. I find myself drawn more strongly to people than to things	definitely agree	slightly agree	slightly disagree	definitely disagree
16. I tend to have very strong interests, which I get upset about if I can't pursue	definitely agree	slightly agree	slightly disagree	definitely disagree
17. I enjoy social chit-chat	definitely agree	slightly agree	slightly disagree	definitely disagree
18. When I talk, it isn't always easy for others to get a word in edgeways	definitely agree	slightly agree	slightly disagree	definitely disagree
19. I am fascinated by numbers	definitely agree	slightly agree	slightly disagree	definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions	definitely agree	slightly agree	slightly disagree	definitely disagree
21. I don't particularly enjoy reading fiction	definitely agree	slightly agree	slightly disagree	definitely disagree
22. I find it hard to make new friends	definitely agree	slightly agree	slightly disagree	definitely disagree
23. I notice patterns in things all the time	definitely agree	slightly agree	slightly disagree	definitely disagree
24. I would rather go to the theatre than a museum	definitely agree	slightly agree	slightly disagree	definitely disagree

25. It does not upset me if my daily routine is disturbed	definitely agree	slightly agree	slightly disagree	definitely disagree
26. I frequently find that I don’t know how to keep a conversation going	definitely agree	slightly agree	slightly disagree	definitely disagree
27. I find it easy to “read between the lines” when someone is talking to me	definitely agree	slightly agree	slightly disagree	definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details	definitely agree	slightly agree	slightly disagree	definitely disagree
29. I am not very good at remembering phone numbers	definitely agree	slightly agree	slightly disagree	definitely disagree
30. I don’t usually notice small changes in a situation, or a person’s appearance	definitely agree	slightly agree	slightly disagree	definitely disagree
31. I know how to tell if someone listening to me is getting bored	definitely agree	slightly agree	slightly disagree	definitely disagree
32. I find it easy to do more than one thing at once	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I’m not sure when it’s my turn to speak	definitely agree	slightly agree	slightly disagree	definitely disagree
34. I enjoy doing things spontaneously	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke	definitely agree	slightly agree	slightly disagree	definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face	definitely agree	slightly agree	slightly disagree	definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly	definitely agree	slightly agree	slightly disagree	definitely disagree

38. I am good at social chit-chat	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc)	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people’s intentions	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people’s date of birth	definitely agree	slightly agree	slightly disagree	definitely disagree

50. I find it very easy to play games with children that involve pretending	definitely agree	slightly agree	slightly disagree	definitely disagree