FIGURATIVE LANGUAGE PROCESSING IN SCHIZOPHRENIA

BY

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ABSTRACT

When patients diagnosed with schizophrenia process figurative language, they often make literality and/or concreteness mistakes. These mistakes can be related to certain cognitive functions that are underperforming or impaired in schizophrenia. This research found that cognitive functions that often present deficits in patients with schizophrenia (PwS) are working memory, cognitive control, cognitive flexibility and ToM. The aim of this study is to provide evidence of the cognitive impairments that might be underlying poorer figurative language processing in schizophrenia, as well as to shed a light on the cognitive functions that might be at play when figurative language is processed. Disclosing the cognitive functions that can be underperforming in schizophrenia can be relevant for therapeutics and for the development of more effective forms of treatment for the disorder. The present thesis analyses figurative language processing (metaphor, logical metonymy and irony) and theory of mind using eye-tracking and behavioural tasks, both on-line and off-line, to disclose how strongly literality and concreteness of language are present in schizophrenia and how closely related these phenomena are to specific deficits in cognitive functioning.

DEDICATION

To all members of my family, both alive and deceased, from whom I have learned to cherish the search for knowledge.

To my husband and daughter, my special gratitude for having been generous enough to understand my feelings and support me in this quest.

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LIST OF ACRONYMS AND ABBREVIATIONS

1. PwS: Patients with Schizophrenia
2. WAIS-IV: Wechsler Adult Intelligence Scale
3. SCID: Structured Clinical Interview for DSM-IV
4. PANSS: Positive and Negative Syndrome Scale
5. KDEF: Karolinska Directed Emotional Faces Test
6. DSM-IV: Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition

Chapter 1

1. GENERAL INTRODUCTION

1. General Introduction

Research describing cognitive deficits involved in schizophrenia, such as that presented here, has increased lately (Addington & Addington, 1993; Aiken, Daly & Soni, 1993; Kuperberg, 2010a, 2010b; Kuperberg, 2000; Kuperberg & Heckers, 2000; Langdom et al., 2002;). Deficits reported often refer to visual attention (Addington & Addington, 1993), memory (Mueser, Blanchard & Bellack, 1995) and language impairments (Kuperberg, 2010a, 2010b; Kuperberg, 2000; Langdom et al., 2002). Why would language deficits in schizophrenia be relevant for studies in language processing or neurocognition? As a matter of fact, studies on language impairments in schizophrenia have been able to provide insights into the impact of brain function in the human capacity of processing and producing language.

Language skills, just as motor skills, are key to human development and have had a crucial role in human evolution. Language has brought humans together in such a sophisticated fashion that we can today share knowledge, communicate worldwide, share goals, work together and accomplish things our ancestors never thought possible. Language is a vital human tool, it is one crucial differentiation between ours and other species that only became possible with the brain growth (encephalisation pattern) that started with the Homo habilis. Hence, learning about language is also learning about the brain and its development. Language processing in psychiatric pathologies, like schizophrenia, can only help unveil the relationship between brain and language. Learning what makes language a more effective tool for some people and not so much for others can only be a valuable and relevant contribution to science, as it can help us understand the boundaries of a fascinating human skill: the capacity to produce and understand language.

Studies on language deficits present in patients diagnosed with schizophrenia (PwS) have mostly tested adult patients after receiving a diagnosis and they have not investigated the cognitive correlates linked with lower performance in specific language skills, such as figurative language processing. The present thesis aims to clarify the role of underdeveloped language functions present in schizophrenia, mainly the ones connected with figurative language processing, as well as disclose the cognitive deficits associated with such deficits.

Problems in understanding figurative language and other cognitive deficits in patients diagnosed with schizophrenia (PwS) were first identified by psychiatrists more than 60 years ago (Benjamin, 1944; Finckh, 1906) and tests using metaphorical proverbs for measuring severity of abstract thinking impairment in schizophrenia were introduced decades ago. However, the impaired cognitive mechanisms underlying figurative language processing in schizophrenia remain unclear and this is precisely what this thesis aims to contribute. The scope of this thesis is the investigation of the cognitive processes involved in figurative language processing among patients diagnosed with schizophrenia who have been undergoing regular psychiatric treatment with second generation anti-psychotics for more than 10 years and to compare their figurative language processing performance to that of neuro-typical controls.

The investigation of the cognitive correlates associated with difficulties in figurative language processing in schizophrenia can contribute to a disclosure of the neurocognitive functions that might not be working so efficiently in the disorder and ultimately help in the development of therapeutics. If therapies were designed to tackle precisely the functions that seem to be underdeveloped or deficient in PwS, then it would mean that patients would be able to improve their cognitive performance, their language use and improve the quality of their social interactions. Cognitive and language impairments related to schizophrenia can represent a challenge for patients, carers and for the community. Being able to overcome them, even if only partially, can be highly beneficial to patient integration in society.

Addington and Addington (1998) reported poorer visual attention in patients diagnosed with schizophrenia and that the presence of negative symptomatology significantly correlated with visual attention deficits in the disorder. Mueser, Blanchard and Bellack (1996) reported that impaired memory correlated positively with poorer social skills in women diagnosed with schizophrenia. Kuperberg (2000, 2010a, 2010b) and Kuperberg and Heckers (2000) reported impairments in working and semantic memory, semantic priming, sentence processing, source monitoring and speech perception, with semantic memory, semantic priming and sentence processing deficits being related to thought disorder and source monitoring and speech perception deficits related to auditory hallucinations. Nonetheless, most of the research has not focused exclusively on figurative language processing and its relationship with specific cognitive measurements, such as working memory, cognitive control and flexibility of thought.

The fact that certain patients diagnosed with schizophrenia displayed difficulties in performing proverb interpretation tasks (“Too many cooks spoil the broth”, “Space is bad for so many people to do one thing”; “Don’t cross the bridge until you come to it”, “Don’t worry about things you can’t control”) was considered by psychiatrists in the 20th century as an indication of “literality” (first example) or “concretism” (second example)[1], a characteristic that became related to schizophrenia and is nowadays also reported to be found in some patients with dementia and patients

[1] Literality: interpretation of words in their primary meaning; concreteness: interpretation of words in a secondary or more abstract meaning, but still not context-appropriate.

with Parkinson Disease whose verbal working memory skills are impaired (Monetta & Pell, 2007).

When manifested as a symptom in patients diagnosed with schizophrenia, concreteness of language seems to suggest that the patient is somehow not able to grasp the speaker's intentions. If we consider certain forms of figurative language processing, such as irony, for example, which requires comprehension of the interlocutor's intention, a deficit in mentalising skills could lead to a patient not performing as expected in tests assessing irony understanding. Hence, this thesis aims to uncover the relationship between mentalising skills and figurative language processing, not only irony, but also metaphor and metonymy.

This thesis presents an analysis of figurative language processing in schizophrenia (metaphor, logical metonymy, irony) and theory of mind aiming at disclosing some of the underlying cognitive mechanisms related to the literality and concreteness of language hypothesis for figurative language processing in schizophrenia. Additionally, this research will help unveil the reality of the existence of literality and concreteness of language in patients who have been on second generation anti-psychotic medication for more than 10 years and help shed a light on the cognitive processes that could remain impaired, even after treatment has been steady for a long time. The various studies that revealed certain cognitive impairments associated with schizophrenia have argued that these deficits characterise the disorder, even perhaps reflecting psychological markers or a personal vulnerability to schizophrenia (Addington & Addington, 1993). As this thesis will present studies that tested outpatients who had been on regular and enduring second generation anti-psychotic medication, it will be able to help clarify aspects in relation to the existence of cognitive markers in schizophrenia.

1.1. Other Types of Figurative Language and Non-literal Expressions

There are many kinds of figurative and non-literal expressions. For example, idioms such as *kick the bucket* share some similarities with proverbs, but don't incorporate advice or a truism and their meaning is often unrelated to the meanings of their individual words. Research in idiom processing in schizophrenia has reported mixed results, and it's unclear whether patients diagnosed with schizophrenia have an actual deficit in idiom processing. Some findings report that PwS only display difficulties in supressing the competing literal meanings, but not in understanding the non-literal meanings (Titone et al., 2002), while other findings report no differences in comprehension of idiomatic sentences between PwS and controls (Pesciarelli et al., 2014). Contrasting findings (Sela, Lavidor & Mitchell, 2015; Tavano et al., 2008), however, do report that PwS present a deficit in idiom comprehension, with Sela et al. (2015) suggesting that a dysfunctional cognitive control could be connected to flaws in idiom perception in PwS.

Titone et al. (2002) also suggested that literally plausible idioms, such as *kick the bucket* presented a challenge for PwS, but not literally implausible idioms, such as *be on cloud nine*. In this case, PwS presented difficulties in inhibiting literal interpretations of the idioms which would compete with the idiomatic ones, requiring contextual disambiguation, not always straightforward for PwS.

1.2. Schizophrenia: aetiology and recent research

Schizophrenia aetiology remains relatively unknown. Recently however, schizophrenia research has broken into genetics and a few recent studies (Sekar, Bialas, de Rivera, Davis, Hammond, et al., 2016) have been able to link complex complement component variations of a gene (complement component 4) with risk for schizophrenia development. This was considered an advancement in the disclosing of the underlying biological mechanisms related to the disorder, as before this study, other genetic studies (Ripke, Neale, Corvin, Walters, Farh, Holmann, et al., 2014) unfolded the genetic regions (loci) associated with the disorder, never having been able to previously identify a variation in a gene as connected with risk for developing schizophrenia. As genetic regions (loci) are not so helpful for gene tracking, the risk signal sources remained unknown. It has been revealed by the most recent study (Sekar, Bialas, de Rivera, Davis, Hammond, et al., 2016) that a region on chromosome 6 contains the genes that deliver the greatest risks associated with schizophrenia. This region on chromosome 6 has genes responsible for acquired immunity, and the loci that showed the most relevant associations were near the gene C4. The variation in gene C4 alone has finally been appointed as relating to risk for schizophrenia development, although other gene variations that could be associated with schizophrenia development risk remain to be found. The main hypothesis in Sekar et al.'s study (2016) for schizophrenia aetiology is a loss of healthy brain synapses (synaptic pruning) during adolescence associated with variations in gene C4.

An earlier study (Boska, 2010) had suggested that the decreased cell density in schizophrenia could be connected to a decreased neuronal density, decreased neuronal size and decreased neuropil (axons + dendrites + glia) that could cause a reduction in grey matter that is often observed in PwS. Falaudi and Mirnics (2011) suggested that adult patients diagnosed with schizophrenia don't have the same number of synaptic connections in various brain regions when compared to neurotypical controls. Postmortem brain studies (Garey, 2010; Glantz, Lewis, 2000) also reported a decrease in dendritic spine density and dendritic architecture on the pre-frontal cortex. These studies hypothesised that schizophrenia could be a neurodevelopmental disorder manifested in pre-frontal microcircuits. As we know, the pre-frontal cortex has been related to executive function performance in attention and memory (Goldman-Rakic, 1997) and more recent studies (Koechilin, Ody & Kouneiher, 2003) have connected this region of the brain with cognitive control and the ability to balance thoughts and goal-directed actions.

The dopamine hypothesis, which claims that schizophrenia symptoms relate to a hyperactive dopaminergic signal transduction, and, so far, the mainstream line of schizophrenia understanding, but not of its aetiology, has dominated schizophrenia treatment, as the first neuroleptic drugs acted therapeutically on blocking dopaminergic receptors in the brain, causing side effects of adrenergic, serotoninergic, cholinergic and histaminergic blockage as well, inhibiting psychomotor functions.

Some recent studies (Moncrieff, 2009) claim that dopamine blockage only proves that the drugs act in reducing hallucinations and delusions, two major symptoms of the disorder, but they only produce a general neurological depression that produces a reduction in these symptoms, but the effect of dopamine activity reducing drugs in decreasing hallucinations and delusions does not demonstrate the causality between overactivity of dopamine and schizophrenia. Treatment of schizophrenia has grossly up to now produced a neurological depression that acted mostly on prominent positive[2] symptoms, such as hallucinations and delusions.

Other earlier studies (Reynolds, 1988) also claimed that measurements of dopamine metabolites in vivo and in post-mortem brain tissue do not give explicit evidence of a relationship between increased dopamine synaptic transmission and schizophrenia. What such studies highlighted was a possible relationship between neuron loss in specific regions that could result in increased action of other limbic dopamine neurons, that ultimately benefited from dopamine-blocking drug treatment to reduce their activity, but not really acting on the underlying causal mechanisms related to the disorder.

In fact, a patient who took part in the present study reported that medication hasn't helped him much and that even after being on medication for a long time, he had not experienced a decrease in a strong feeling of loss generated by the social and professional limitations imposed by society on PwS which often lead to financial instability. Yet, this patient reported that medication didn't help overcome feelings of vulnerability in relation to, for example, hypersensitivity to specific noises or sounds like coughs, traffic, feet and wheels, which seem to cause him distress and anxiety. Other patients report to experience a reduction in positive symptoms, but not in negative symptoms[3].

The overactive synaptic pruning hypothesis as connected to a genetic variation, especially linked to structurally diverse alleles of a specific complement component

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[2] Positive symptomatology refers to supplementary properties that are added to a patient's daily experience of life, such as hallucinations and delusions. In this case, positive means "more than" or additional, not good. Positive symptoms commonly lead to a loss of touch with external reality.

[3] Negative symptoms are the opposite of positive symptoms, they express behaviours the person usually presented before the manifestation of the disorder and that they no longer display. Negative symptoms are commonly related to lethargy, apathy, social withdrawal, reduction in speech and anhedonia (inability to experience pleasure).

(C4) sounds like a more promising path if compared to the dopamine hypothesis, as the underpinning neurobiological mechanisms of schizophrenia could be more clarified. However, schizophrenia studies still have a long way to go before finally disclosing the causality of the disorder and developing more effective forms of treatment. Research in cognition in schizophrenia can only help uncover the reality that this disorder goes beyond the mere symptomatology of hallucinations and delusions and that it encompasses broader neurodevelopmental deficits whose aetiology remains to be revealed.

If we consider, for example, that children at risk of developing schizophrenia already present neurodevelopmental delays and that other neurodevelopmental studies (Johnstone, Ebmeier, Miller, Owens, 2005) have included language and motor performance deficits as risks for later adult psychopathological development, including schizophrenia development, then we would have to question whether schizophrenia as a disorder would fall into a categorical classification developed in adolescence or would be a neurodevelopmental disorder that results from interactions between genetic proneness and environment, with genetic proneness being more or less likely to be manifested depending on the degree of genetic proneness and degree of environmental disadvantage.

Although synaptic pruning in adolescence as connected to a genetic variation of complement component 4 can be an exciting new promise in unveiling schizophrenia aetiology, we must still consider the neurodevelopmental aspect involved in the disorder and the reported presence of neurocognitive deficits since early childhood only supports this idea (Johnstone et al., 2005). The loss of healthy brain synapses occurring in adolescence might only reinforce and add to previous synaptic connections that had not been occurring as expected. In the neurodevelopmental view, there is a risk for developing schizophrenia that is already present since early childhood. Other contributing factors, such as childhood adversities can trigger the manifestation of the disorder.

1.3. Thesis Presentation and Structure

The following brief review presents an analysis of figurative language processing in schizophrenia (metaphor, logical metonymy, irony) and theory of mind aiming at disclosing the reality of the literality and concreteness hypothesis for figurative language processing in schizophrenia, as well as investigating the cognitive processes that could be impaired for PwS and that could be preventing them from properly understanding figurative utterances.

The structure of the present thesis is organised as follows: Chapter 2 presents the two stages of cognitive assessment of all participants, from both the patient and the neurotypical control group. The goal of the first stage assessment is to control participants for general cognitive functions involved in reading and interpreting figurative language extracts. We aimed to control participants for verbal comprehension IQ, general IQ and reading skills on a first stage and later, on a second stage, we tested participants who did not display significant discrepancies on the first stage. The second stage included tests on Theory of Mind (perspective-taking and mentalising), facial emotion recognition, cognitive flexibility, auditory-verbal working memory and cognitive control. A principal component analysis of the factors extracted for all the second stage test battery is presented in this chapter.

Chapter 3 presents a Theory of Mind study. It reports and analyses results obtained from the Perspective-taking Task, the Hinting Task and the Karolinska

Directed Emotional Faces Test – KDEF (Lundqvist, Flykt, & Öhman, 1998). A second principal component analysis is included, excluding the Perspective-taking Task. The aim of the second PCA analysis was to unveil the relationship between the variables from the second battery of tests and the Perspective-taking variables. Chapters 4, 5 and 6 present the irony processing study, the metaphor processing study and the logical metonymy processing study. Each chapter displays results and analyses of two experiments, an eye-tracking one and an offline sentence interpretation task. To investigate the cognitive correlates of figurative language processing in both groups, we present correlation results between the components extracted in the first PCA analysis and the figurative language effect in each chapter.

Finally, in the general discussion of the thesis, we summarise our findings and draw conclusions based on the results obtained. Cognitive correlates related to figurative language processing are outlined for each type of figurative language studied and differences between these different types of figurative language are highlighted. Additionally, specific figurative language differences in both processing and cognitive correlates for each group are detailed in this chapter.

Chapter 2

PARTICIPANTS' COGNITIVE ASSESSMENT AND FIRST PRINCIPAL COMPONENT ANALYSIS

2.1. Participants' Cognitive Assessment

As we intend to unveil the underlying cognitive mechanisms associated with figurative language processing, we ran two separate batteries of cognitive tests in order to control all participants on basic cognitive functions (battery 1) and to assess their performance on cognitive skills that have been implicated in figurative language processing (battery 2; e.g. Spotorno, Koun, Prado, Van Der Henst, & Noveck, 2012). Performance on the second battery will be analysed using independent samples *t*-tests and Principal Component Analysis (PCA). Results of the PCA will be used in the analyses of the ToM, irony, metaphor and metonymy data.

The first battery involved cognitive skills. Because participants needed to have similar reading and verbal comprehension IQs to avoid possible confounds in our data, we decided to run a first set of cognitive tests in order to select the patients that could in fact take part in our study without causing data bias. For the purpose of verbal and reading skills matching, all the WAIS-IV sub-tests related to verbal IQ and working memory were used, as well as the Gray Silent Reading Test (GSRT, Wiederholt & Blalock, 2012), a test that measures silent reading comprehension skills. We used patients and controls who did not display significant differences in accuracy on the first battery of tests (see below). Considering that patients and controls were matched for social and educational background, as well as verbal IQ, and had been on second-generation anti-psychotic medication for more than ten years, we can say that the patient population who took part in this study was not the usual population of inpatients used in various previous studies of schizophrenia (Carter, Robertson, Nordahl, Charderjian & Oshora-Celaya, 1996; Cohen, Barch, Carter & Servan-Schreiber, 1999; Corcoran, Mercer & Frith, 1995; Cornblatt & Keilp, 1994); therefore, we can expect these patients to be functioning cognitively in a more effective way than inpatients.

Because we wanted to avoid a bias in our data, the second battery was administered to patients and controls who were matched in the first cognitive battery assessment. Patients who displayed significant discrepancies in the basic cognitive functions' battery (battery 1) required to process the figurative language stimuli were not used for the second stage of the study. During testing of battery 1, we noticed that even though most patients were comparable in accuracy to controls, they tended to take longer to respond in certain tasks (response latencies are not measured in the WAIS-IV tests) and their answers did not come as straightforwardly as answers given by controls, especially in tasks involving working memory and flexibility of thought. We therefore ran a second battery of tests to evaluate these cognitive skills further. We included ToM tasks to investigate the hypothesis that ToM is related to irony processing in reading (Spotorno et al., 2013) and possibly other types of figurative language processing. Detailed results related to this investigation can be found in Chapter 4.

Tests in battery 2 included the Hinting task (Corcoran, Mercer, & Frith, 1995), a task on Theory of Mind and mentalising skills in indirect utterances, an on-line Perspective-Taking task (Samson et al., 2010), measuring the ability to switch perspectives, a facial emotion recognition task, the Karolinska Directed Emotional Faces Test – KDEF (Lundwist, Flyict, & Ohman, 1998) a Cognitive Control task (designed by the author, see Appendix A for details) and four sub-tests of the Test of Everyday Attention (TEA, Robertson, Ward, Ridgeway & Nimmo-Smith, 1994): the Elevator Counting with Distraction, the Elevator Counting with Reversal, Visual Elevator 1 and Visual Elevator 2. The TEA (Robertson et al., 1994) sub-tests are measures of audio-verbal working memory and flexibility of thought. We included the TEA as the ability to manipulate information in working memory seems relevant for contextual processing in language (Kuperberg, 2010a; 2010b), and deficits in working memory have been implicated in higher cognitive dysfunctions in schizophrenia, such as attentional deficits (Carter, Robertson, Nordahl, Charderjian & Oshora-Celaya, 1996). The perspective-taking task involves participants judging self and other perspective (represented by an avatar) in trials where the avatar's and participant's point of view coincide (consistent trials) and in trials where their point of view do not coincide (inconsistent trials). More details of this task, as well as details of the Hinting Task and the on-line perspective-taking task can be found in Chapter 3.

The Cognitive Control task aims at measuring inhibition of irrelevant cognitive activations and the ability to quickly change the train of thought. Deficits in cognitive control have been considered a distinctive feature of schizophrenia (Green, 1996; Green, Kern, Braff, Mintz, 2000; Lesh, Niendam, Minzenberg & Carter, 2010) and cognitive control has even been proposed as a unifier of most of the general cognitive abnormalities found in the disorder (Lesh et al., 2011). Finally, the Karolinska Directed Emotional Faces Test (KDEF), in which participants must recognise seven different facial emotions in pictures displayed in 70 different face angles, has been used for the measurement of perception skills and interpretation of facial emotional expressions skills, as these can be relevant for more effective social interaction (Goeleven, Raedt, Leyman & Verschuere, 2008). Research has shown that in-patient PwS perform worse than controls on the KDEF, especially when judging happiness and surprise (Larøi, Fonteneau, Mourad, & Raballo, 2010).

It should be noted that the Cognitive Control Task used for the PCA analysis is not a standardized measure, but a task developed by the author. An independent samples *t*-test showed that patients' performance ($M = 6.48$, $SD = 2.98$) on this task was significantly below controls' ($M = 9.00$, $SD = 3.46$), $t(44) = 2.65$, $p < .05$. The degree of difficulty (scale from 1 to 10) on the Control and Flexibility Task perceived by participants was also significantly different in both groups, with patients ($M = 5.04$, $SD = 2.24$) reporting it significantly more difficult than controls ($M = 3.33$, $SD = 2.52$), $t(44) = 2.43$, $p < .05$. Performance on this task strongly correlated with other individual measures, such as the TEA Elevator Counting with Distraction ($r = .529$, $n = 25$, $p < .01$), the TEA Visual Elevator 1 ($r = .502$, $n = 25$, $p = .01$), and the cognitive variables measured in the PANSS[4] ($r = -.408$, $n = 25$, $p < .05$). The latter

[4] The "cognitive dimension of the PANSS" (Hofer et al., 2007; Nielsen, Lindström, Telléus, Levander, 2014) is a compound of four cognitive variables measured in the PANSS within the three main axes (positive, negative and general symptomatology), conceptual disorganization, difficulty in abstract thinking, disorientation and poor attention.

finding is notable as it indicates that patients who scored higher on the Control and Flexibility task showed a lower degree of cognitive impairment as measured by the PANSS. In short, while this task has not been used previously, it does seem to tap into processes also found in more established tests, such as the WCST (Wisconsin Card Sorting Test). We chose to develop a novel cognitive control task because we wanted to have a task which involved cognitive control in language processing skills. The WCST is mainly a task-switching test where people are required to classify cards according to certain criteria. The WCST was found to correlate positively with other flexibility of thought tasks in the TEA (Robertson et al., 1994) used in the second battery. Further information on the second battery of tests is displayed in Table 1.

Table 1: Battery 2 – Tests used

AUTHOR	NAME - BRIEF DESCRIPTION	SKILL INVOLVED
Robertson et al. (1994)	TEA Visual Elevator - Participants count "floors" up or down following the arrows representing the way the elevator is going	Cognitive flexibility
Robertson et al. (1994)	TEA Visual Elevator - Time participant takes to switch up or down at each arrow	Cognitive flexibility
Robertson et al. (1994)	TEA Elevator Counting with Distraction - Participants must count the low tones and ignore the high tones they hear as they go up and down in the pretend elevator	Auditory-verbal working memory
Robertson et al. (1994)	TEA Elevator Counting with Reversal - Participants must count floors up or down when hearing high-pitched (up) or low-pitched (down) tones	Auditory-verbal working memory
Lundwist et al. (1998)	Karolinska Directed Emotional Faces Test - Participants must recognise facial emotions by looking at pictures on the screen from different face angles	Facial emotion recognition
Samson et al. (2010)	Visual on-line perspective-taking task - Participants must click "yes" or "no" on the mouse while responding to questions referring to the number of circles on the wall seen by avatar or participants themselves	Perspective-taking

Helena de Andrade Conde (2015)	Cognitive control task - Participants must link the first letters of the words in each sentence on the left to meaningful or meaningless words formed by these letters on the right as quickly as possible	Cognitive control

2.2. Method

2.2.1. Participants

Patients: Twenty-five patients (average age 40; range 20-55) with a diagnosis of schizophrenia were tested. They had an average of 14 years of formal education (range: 9-22) and had been on second-generation anti-psychotic medication for an average of 15 years (range: 11-19). All patients were submitted to the PANSS (Positive and Negative Syndrome Scale) questionnaire (Kay, Fitzbein & Opler, 1987) and the Structured Clinical Interview for DSM-IV/SCID (First, Williams, Spitzer, Gibbon & Miriam, 2007), specifically the Psychotic Symptoms Questionnaire. Sixteen participants received a classification of current paranoid schizophrenia and 11 participants had a single episode that was classified as paranoid schizophrenia and were currently in partial remission.

Controls: Twenty-one participants (average age 30; range 20-55) who had never received a diagnosis of mental disorder participated in the study. They had an average of 13 years of formal education (range: 11-19). None of these controls had ever been on any psychiatric medication, nor had any of their first-degree relatives. Control participants were also submitted to the SCID, the non-patient questionnaire part of the interview, including the Screening Module.

All participants answered the Hollingshead Four Factor Index of Social Status questionnaire, and both patient and control group had similar socio-educational and socio-economic backgrounds. The number of university graduates in each group was the same (3).

2.2.2. Battery 1: Cognitive Skills Matching

All participants were tested for verbal comprehension IQ and working memory with the WAIS-IV and reading comprehension with the GSRT (Wiederholt & Blalock, 2012). Means and standard deviations can be found in Table 2. All comparisons were calculated using percentages. The groups did not significantly differ on each sub-test of the WAIS-IV used for this stage and the GSRT did not significantly differ either (all *p*s > .50).

Table 2: Cognitive skills assessment - Battery I

Test	Patients (SDs)	Controls (SDs)
WAIS-IV		
Similarities WAIS-IV	57.8% (4.47)	59.7% (5.27)
Vocabulary WAIS-IV	56.4% (8.81)	52.9% (9.77)
Information WAIS-IV	57.4% (4.15)	49.7% (5.22)
Comprehension WAIS-IV	53.7% (4.34)	55.2% (4.35)
Digit span forwards WAIS-IV	78.7% (2.27)	78.2% (2.21)
Digit span backwards WAIS-IV	57.2% (2.55)	59.2% (2.92)
Digit span sequencing WAIS-IV	47.7% (1.49)	49.8% (1.72)
Arithmetic WAIS-IV	63.8% (3.85)	68.5% (3.96)
Letter-number sequencing	58.7% (4.41)	62.6% (2.9)
GSRT	60.4% (5.3)	63.0% (5.41)

2.2.3. Battery 2: Detailed Cognitive Skills Assessments

Results for the tests used in the second battery of tests can be found in Table 3.

Table 3: Cognitive skills assessment - Battery 2: Means Comparisons

Tests	Patients	Controls
Perspective-Taking Task Errors Consistent Self	1.40 (2.38)	3.16 (7.04)
	t = 1.545, p = .129	
Perspective-Taking Task Errors Consistent Other	1.76 (3.26)	1.04 (1.21)
	t = 1.571, p = .123	
Perspective-Taking Task Errors Inconsistent Self	4.0 (3.30)	6.80 (10.63)
	t = 1.352, p = .183	
Perspective-Taking Task Errors Inconsistent Other	6.44 (9.66)	3.36 (3.85)
	t = 1.571, p = .123	
KDEF	53.52 (7.04)	56.71 (6.60)
	t = 1.738, p = .089	
Hinting Task Score	72.4 (2.80)	80.25 (2.56)
	t = 2.132, p < .05*	

Hinting Task Time	450.44 (105.58)	358.95 (84.17)
	t = 3.683, p = .001**	
Degree of Difficulty in the Hinting Task	3.72 (1.85)	2.07 (1.03)
	t = 3.559, p = .001**	
TEA Visual Elevator 1	8.76 (3.67)	9.71 (3.58)
	t = 889, p = .378	
TEA Visual Elevator 2	4.04 (2.26)	5.95 (3.33)
	t = 2.30, p < .05*	
Elevator Counting with Reversal	9.28 (3.30)	8.62 (4.29)
	t = .590, p = .558	
Elevator Counting with Distraction	8.60 (3.05)	9.48 (2.64)
	t = 1.030, p < .309	
Cognitive Control Task Score	6.48 (2.99)	9.00 (3.46)
	t = 2.65, p < .05*	
Degree of Difficulty in the Cognitive Control Task		
	5.04 (2.24)	3.33 (2.52)
	t = 2.43, p < .05*	

Note: Perspective-taking errors, Hinting Task and Cognitive Control Task scores are in percentages, TEA scores are in scaled scores, Hinting Task Time is in seconds and represents the average time each group took to finish the Hinting Task. Standard deviations can be found in brackets. Degrees of freedom for the t-test = 44.

Means comparisons revealed that patients and controls significantly differed in cognitive control, in the degree of difficulty in the Cognitive Control task, in the TEA Visual Elevator 2 (flexibility/time to change the train of thought), in the Hinting Task time, in the Degree of Difficulty in the Hinting Task and in errors they made when analysing inconsistent other trials in the Perspective-taking task.

It seems that cognitive control, flexibility, mentalising skills and perspective-taking (ToM related variables) are sensitive areas of discrepancy between groups.

2.2.3.1. Correlations between the Cognitive Control task and other tests used in battery 2

We ran correlation analyses between the Cognitive Control task and the other tests used in the second battery in order to verify how this task, which was designed by the candidate, integrated with the other tests used in battery 2. Results can be found in Tables 4 (control group) and 5 (patients).

Table 4: Correlations between the Cognitive Control task and Battery 2 Tests – Control Group (n = 21)

Test	TEA Elevator Counting with Reversal	TEA Visual Elevator 1	Degree of Difficulty in the Cognitive Control Task
Cognitive Control Task	$r = .484$, $p < .05$	$r = .569$, $p < .01$	$r = -.619$, $p < .01$
Degree of Difficulty in the Cognitive Control Task	$r = -.469$, $p < .05$		

The results showed that better working memory skills and better flexibility of thought related to control participants finding the Cognitive Control task easier, that is, sharper working memory and good flexibility skills made the task easier, increasing performance scores on it.

Table 5: Correlations between the Cognitive Control task and Second Battery Tests – Patient Group (n=25)

Test	TEA Elevator Counting with Distraction	TEA Visual Elevator 1	PANSS Positive	Cognitive Dimension of the PANSS	Degree of Difficulty in the Cognitive Control Task
Cognitive Control Task	$r = .529, p < .01$		$r = -.399, p < .05$	$r = -.408, p < .05$	$r = -.388, p = .055$
Degree of Difficulty in the Cognitive Control Task	$r = -.469, p < .05$	$r = .502, p = .010$			

Correlations results for patients were similar, revealing that the better the flexibility of thought and working memory skills were, the fewer the difficulties in the Cognitive Control task. Interestingly, the higher the score in the PANSS Positive, the lower the score in the Cognitive Control task. Likewise, the higher the score in the Cognitive Dimension of the PANSS (Hofer et al., 2007; Nielsen, Lindström, Telléus, Levander, 2014), a compound of four cognitive variables measured in the PANSS (conceptual disorganization, difficulty in abstract thinking, disorientation and poor attention), the lower the score in the Cognitive Control task. Hence, this novel task seems to tap into relevant executive functions that concern the present study.

Results from both groups suggest that flexibility and working memory are cognitive skills that can promote more successful scores in the Cognitive Control task for all participants. Inversely, the less efficient these skills, the more likely that the Cognitive Control task scores will be lower.

2.2.3.2. Correlations between Positive and Negative symptoms, Thought Disturbance, the Cognitive Dimension of the PANSS and other second battery tests

Correlations between positive and negative symptoms, thought disturbance, the cognitive dimension of the PANSS and the other second battery tests, apart from the Cognitive Control task, revealed that mentalising skills, abstract thinking, organisation, orientation and attention (cognitive dimension of the PANSS) decrease if the patient is more affected by positive symptomatology. Likewise, negative symptomatology decreases the cognitive dimension of the PANSS, as well as make the patient take longer to change their train of thought. Negative symptomatology is also connected to thought disturbance and passive apathetic social withdrawal. Poorer attention, orientation, abstract thinking and organisation also seem to impact facial emotion recognition. Results for these correlations can be found in Table 6.

Table 6: Correlations between Positive and Negative symptoms, Thought Disturbance, the Cognitive Dimension of the PANSS and other second battery tests (Patients only; n=25)

Test	KDEF	Hinting Task (Score)	Hinting Task (Time)	TEA Visual Elevator 2	Cognitive Dimension of the PANSS	Passive Apathetic Social Withdrawal	Thought Disturbance
PANSS Positive		$r = -.524, p < .01$	$r = .484, p < .05$		$r = .534, p < .01$		$r = .600, p < .01$
PANSS Negative				$r = -.448, p < .05$	$r = .483, p < .05$	$r = .501, p < .05$	$r = .467, p < .05$
Cognitive Dimension of the PANSS	$r = -.462, p < .05$						

2.2.4. Principal component analysis of battery 2 tests

We conducted a principal component analysis (PCA) in R (R Core Team, 2016) using variables from battery 2 to find out which variables accounted for most of the variance in the data and how they clustered to form the principal components. Before running the principal component analysis, we ran a Bartlett's test to determine whether we had an identity matrix in our correlation matrix and a KMO test to identify the degree of common variance in the data and to check whether it would be appropriate for PCA. Five components were retained based on the Kaiser's Rule. Components were named based on the strongest positive loadings on each factor. Negative loadings were considered exclusionary, as they suggest an inverse relationship to the compound expressed by the factor. The names in Table 9 below reflect the essence and commonalities of the major loadings for each factor (Wu, Larrabee, & Putman, 2006; Zea, Asner-Self, Birman, & Buki, 2003).

The principal component analysis extracted 13 components from the data set, with eigenvalues ranging from -0.49 to 0.70 (see Plot 1). Standardized loadings (pattern matrix) were based upon the correlation matrix within the data set. The first five components accounted for 71% of the variance and were retained as their loadings were greater than 1. These five components received construct names and appear in order of variance accounted for, as shown in Table 9. Residuals statistics applied to the five components revealed a root means squared residual of 0.076, which was below the 0.08 threshold. The proportion of absolute residuals was slightly above the 0.05 threshold, 0.0526. We then ran a principal component analysis defining only five factors to be extracted from the dataset and applied a varimax rotation to it. The root mean square of the residuals was 0.08. Table 7 displays the results for the 13 components and Table 8 displays the results for the five components kept for the analysis. The cut-off value used was .30.

Table 7: Principal Component Analysis Results

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13
SS loadings	3.64	1.85	1.46	1.22	1.08	0.83	0.65	0.61	0.56	0.38	0.32	0.26	0.14
Proportion Var	0.28	0.14	0.11	0.09	0.08	0.06	0.05	0.05	0.04	0.03	0.02	0.02	0.01
Cumulative Var	0.28	0.42	0.53	0.63	0.71	0.78	0.83	0.87	0.92	0.94	0.97	0.99	1.00
Proportion Explained	0.28	0.14	0.11	0.09	0.08	0.06	0.05	0.05	0.04	0.03	0.02	0.02	0.01
Cumulative Proportion	0.28	0.42	0.53	0.63	0.71	0.78	0.83	0.87	0.92	0.94	0.97	0.99	1.00

Table 8: Principal Component Analysis: Five Factors with Lading Values

Component 1: Flexibility and Working Memory		Component 2: Difficulties in Cognitive Control		Component 3: Errors in Perspective-taking		Component 4: Hinting Comprehension		Component 5: Facial Emotion Recognition	
Elevator Counting with Reversal	.86	Degree of Difficulty in the Cognitive Control Task	.85	Error Analysis Consistent Self	.81	Hinting Task Score	.84	KDEF	.87
TEA Elevator 1	.84	Degree of Difficulty in the Hinting Task	.85	Error Analysis Inconsistent Self	.76	TEA Elevator 1	.30	Elevator Counting with Distraction	.51
TEA Elevator 2	.70	Elevator Counting with Distraction	-.45	Error Analysis Inconsistent Other	.30	Error Analysis Inconsistent Other	-.35		
Elevator Counting with Distraction	.34	Cognitive Control Task	-.69	Error Analysis Consistent Other	-.38	Error Analysis Consistent Other	-.56		
Error Analysis Consistent Other	-.32								
Error Analysis Inconsistent Other	-.43								

% variance	.19	% variance	.17	% variance	.13	% variance	.11	% variance	.11
Cumulative variance	.19	Cumulative variance	.36	Cumulative variance	.49	Cumulative variance	.60	Cumulative variance	.71

The first component labelled “Flexibility and Working Memory”, which accounted for the most variance (19%) in the whole data set (see Table 9), included the TEA sub-tests involving flexibility of thought (TEA Elevator 1 and 2) and audio-verbal working memory (Elevator Counting with Reversal and Elevator Counting with Distraction). Perspective-taking skills were negatively loaded on this component, which means that Perspective-taking correlates negatively with the major positive components in this factor, so people with more effective working memory skills and more effective cognitive flexibility tended to make fewer errors in judging the “Other” perspective, both in consistent and inconsistent trials.

The second component labelled “Difficulties in Cognitive Control”, which accounted for 17% of the variance in the total data set, included the degree of difficulty in performing two of the tasks, the Cognitive Control Task and the Hinting task. The negative covariance in this component indicated that the higher the degree of difficulty in the Cognitive Control task covaried with lower scores in this task. Additionally, the more difficulties presented in the Hinting Task, the lower the scores in the Elevator Counting with Distraction sub-test, which taps into audio-verbal working memory. The higher the degree of difficulty in both the Cognitive Control and the Hinting Task, the lower the scores in the Cognitive Control Task and the TEA Elevator Counting with Distraction (working memory).

The third component labelled “Errors in Perspective-taking” and accounting for 13% of the total variance in the data set, had its main loadings from perspective-taking skills. In the on-line Perspective-taking task, consistent and inconsistent trials evaluating the “Other” perspective inversely covaried, suggesting that when judging the “Other” perspective, errors arose more substantially when participants had to juggle the discrimination between their own and the avatar’s perspective. The fourth component labelled “Hinting Comprehension”, which accounted for 11% of the variance in the data set, had its major loading from the Hinting Task score, more than double the loading of the TEA Elevator 1 sub-test, the second positive variable in the component, suggesting that hinting comprehension skills were the most prominent variable in this component. According to this component organisation, we can see that more effective hinting comprehension skills correlate with fewer errors when judging the "Other" perspective, which makes sense and adds to the robustness of the model. The fifth component labelled "Facial Emotion Recognition", which also accounted for 11% of the variance in the data, had facial emotion recognition as its major loading in the component with the TEA Elevator Counting with Distraction sub-test following, but not closely. As the TEA Elevator Counting with Distraction had already been accounted for in component 1, the fifth component had facial emotion recognition as its more relevant naming variable. In component 5, facial emotion recognition (KDEF) appeared to covary with the results from the TEA Elevator Counting with Distraction sub-test (working memory), suggesting that these variables might be connected in some way (see Table 9).

2.2.5. General Discussion

The PCA analysis produced component groupings that accounted for most of the variance in the data. Results indicated that most of the variance in the second cognitive battery data was localised in working memory, flexibility, difficulties in cognitive control, in mentalising, errors in perspective-taking, hinting comprehension and facial emotion recognition, the five factors that accounted for 71% of the variance in the data. We can infer from these results that the data vary mostly across these variables and we can then expect to find major differences between patients and controls exactly in these variables. Additionally, factors did not often display the same variables with similar positive loadings, except the Elevator Counting with Distraction sub-test which loaded positively onto Component 5 (Facial Emotion Recognition) and, to a lesser degree, onto Component 1 (Flexibility and Working Memory).

The PCA analysis revealed that perspective-taking task variables loaded onto the same component as the Hinting Task (Component 4), suggesting that there can be in fact perspective-taking components on the task created by Samson et al. (2010), which challenges Rubio-Fernandez (2017) claim that the Samson et al.'s task limits participants' perspective-taking abilities. If perspective-taking were not a prominent cognitive function tested by the Samson et al.'s task, it would likely not have loaded onto the same component as the Hinting Task.

There were no differences between groups in basic cognitive functions in battery 1. We found significant differences between groups in battery 2 though, including cognitive control, degree of difficulty in cognitive control, flexibility of thought (time to change the train of thought), time to perceive hints in a conversation, the difficulty in perceiving hints in a conversation and the number of errors in analysing inconsistent "Other" trials. These tests load onto four out of five of the components.

As working memory and cognitive control seem to be relevant for language processing according to previous studies (Condray, Steinhauer, Kasparek & Yao, 1995; Kuperberg, 2010) and have stood out as significantly different in mean comparisons between the groups, we can expect that these variables may have an impact on the figurative language processing results. Other variables that also have been reported to bear relevance for irony processing, as, for example, ToM (Spotorno et al., 2012), are also expected to display significant results in the study.

Although there were no significant differences between patients and controls in battery 1, battery 2 did display clear differences between groups, which demonstrates that a few variables seem to point to a deficit in patients' cognitive functioning. These variables are basically cognitive control, degree of difficulty in cognitive control, flexibility of thought, mentalising skills and perspective taking. We can expect to find significant differences between groups in the use of these functions when correlating them with the processing cost that the participants showed during the processing of different types of figurative language (which we will call the *figurative language effect*, see Chapters 4-6).

If the cognitive functions expressed by the PCA components do seem to display differences in relation to how they are used and recruited by PwS and neurotypical controls when correlated with the figurative language effect, then we might be able to discern some of the underlying factors that are at play when PwS process and interpret figurative expressions. In addition, this methodology can also provide us with insights into the cognitive functions that are associated with the different types of figurative language processing, which ultimately will shed more light on the specificities of each type of figurative language.

Finally, while one of the main aims of the thesis is to test how patients and controls process different types of figurative language, we will also relate their performance to the different components that we have identified in the PCA. This will allow us to examine whether patients and controls make use of similar cognitive functions when processing figurative language, or not.

Chapter 3

THEORY OF MIND STUDY

3.1. Introduction

Historically, several studies focusing on mentalising skills in children with ASD (Baron-Cohen, Leslie & Frith, 1985) and in patients diagnosed with schizophrenia (Frith, 1992) claimed that people who received a diagnosis of ASD or schizophrenia tend not to do well in identifying other people's point of view. Psychotic phenomena, such as delusions, a landmark symptom of schizophrenia, often relate to contents where patients report very peculiar feelings or ideas that their thoughts are audible to others. Nickerson (1999), who explored the adult tendency of imputing one's own beliefs to others, claims that when a knowledge base of the other person's judgment is non-existent, a tendency to impute their own judgment to other people arises.

Often, patients who received a diagnosis of schizophrenia have difficulties in recognising the legitimacy of other people's different views. PwS often interpret other people's gestures, even common environmental cues, such as a destination written on a bus stop, as signs directed only to them and to nobody else, like a type of message especially addressed to them. In addition, PwS frequently report that at some point in time they felt they had extraordinary abilities or skills and that they felt they were special in some way, such as, for example, feeling they were the direct descendants of Jesus Christ or that they were famous or wealthy. These symptoms highlight that patients regularly tend to take a rather self-centred position in relation to reality (seeing reality not objectively) that is very hard to change even if evidence proves otherwise. Not being able to admit that one's conceptions could be mistaken in view of evidence, especially when the person in question is an adult, is something that has intrigued psychologists and psychiatrists for years.

In Theory of Mind (ToM) studies, specific neuro-cognitive tasks have been developed to examine how well someone can inhibit their self-perspective and recognise other people's perspectives (e.g. Samson, Apperly, Braithwaite, Andrews, & Scott, 2010; Santiesteban, Shah, White, Bird & Heyes, 2015). When neuro-cognitive functions related to acknowledging somebody else's point of view are underperforming or present a deficit, we can hypothesise that self-perspective would tend to gain a larger dimension, becoming undesirably prominent and overtaking, leading to a more individualised and peculiar interpretation of reality.

We will use an on-line task measuring perspective-taking, the Perspective-taking task, and an off-line task measuring mentalising skills, the Hinting task. According to literature on ToM (Sodian, Thoermer & Metz, 2007), the capacity to theorise about other people's mental states and impute beliefs to others and the ability to recognise other people's point of view develops at an early stage of life. As early as 14 months old, toddlers can already identify that an object that they see can go totally unnoticed by somebody else. Another study involving ToM (Carlson & Moses, 2001) demonstrated a positive correlation between maturity of executive functions and children's ability to put their own perspective aside when tested in false belief tasks.

Birch and Bloom's (2004) study highlighted that, although much more common in children below 4 years of age, egocentric behaviour is a trait that people can sometimes still present in adulthood. In the task reported by Keysar, Lin and Barr (2003), adult participants repeatedly failed to remember that the tape that they had hidden in a bag could not possibly be the one the director was indicating[5]. It became

[5] Keysar et al. (2003) used a version of the Director task to investigate adult people's ability to distinguish between their beliefs and other people's beliefs. In the case of the Director task used, a person who played the role of "director" gave participants instructions to move objects around a grid. Before receiving instructions, participants were supposed to hide an object in a bag that only them, not the director, would know the identity. When the description of the objects given by the

clear that adults in that context displayed an egocentric behaviour and they responded to the director's commands or requests in accordance with their own knowledge of the situation, not the director's knowledge (see also Keysar, 1997; Keysar, Barr, Balin, & Brauner, 2000; for an overview, see Apperly, 2010).

Shifting from your own way of seeing things to another person's way of seeing things involves the ability to inhibit one's own knowledge of the situation, which means that there can be an inhibitory or control process present in the apparent simple act of recognising another person's perspective. In addition, there have been claims that the Director task, often used to measure ToM skills and designed by Krauss and Glucksberg (1977), can involve selective attention, which is a cognitive executive function (Rubio-Fernández, 2017). The fact that the Director Task also places demands on participants' selective attention and consequently on their cognitive control (Rubio-Fernández, 2017) would suggest that for recognising the other person's perspective, good cognitive control skills are needed.

In this sense, if we consider that attention to external stimuli can only happen if there is an inhibition of internal stimuli, we must consider the precedence of inhibitory and control processes when ToM is involved. Inhibitory mechanisms mature with age (Diamond & Taylor, 1996) and that is the reason why younger children are less able to inhibit or control the intrusion of the self-perspective (Diamond & Taylor, 1996). In schizophrenia, it could be the case that inhibitory or control mechanisms are dysfunctional, making it harder for patients to monitor egocentric responses and behaviour. Evidence for this comes from studies that have demonstrated that

director matched the object in the bag, participants often took the hidden object as the one being referred to by the director.

participants diagnosed with schizophrenia tend to do worse in tasks involving executive functions (Weickert et al., 2000), which are not necessarily related to IQ measures. Additionally, results from battery 2 tests (see Chapter 2) revealed that patients and controls significantly differed in cognitive control scores and degree of difficulty in the cognitive control task.

Thought rigidity, a symptom present in the development of delusions, has been linked to poor flexibility of thought (Schultz & Searleman, 2002). Behavioural rigidity was often measured in previous studies with the Wisconsin Card Sorting Test (Schultz & Searleman, 2002), which is a test of cognitive reasoning that has been used since the late 1940's (Grant & Berg, 1948) as a measurement of a patient's level of ability to shift to new responses. This test has been widely used for brain-damaged patients. Other similar task switching tests are also used when a clear brain damage is not involved. The Visual Elevator task from the TEA (Test of Everyday Attention), used in the present thesis, loaded on the same factor as the Wisconsin Card Sorting Test when the TEA was being standardised (Robertson et al., 1994). Both tasks involve attentional switching and measure degrees of deficit in flexibility of thought, one of the executive functions performed in the pre-frontal cortex (Granpeesheh, Tarbox, Najdowski & Kornack, 2014). Previous research (Lysaker, Bryson, Davis & Bell, 2004) had indicated that work performance in PwS was significantly greater when patients did better both in the Wisconsin Card Sorting Test and in the Digit Symbol sub-test of the WAIS-R.

A flexibility of thought measure, as the one used in our cognitive tests, can help us understand the relationship between poorer flexibility skills (thought rigidity) and ToM skills. Recognition of the other person's perspective involves inhibition of self-perspective and switching to the other person's perspective. If someone is not able to switch from one's own perspective to another, it can be an indication that control, and flexibility skills might not be performing as expected.

Finally, in addition to investigating the process of switching from one's own perspective to another person's perspective both in PwS and controls, this chapter will also examine how facial emotion perception recognition interacts with ToM processes in the same groups. Facial emotion recognition is a valuable social cognition skill that is largely used in everyday social interactions (Martino et al., 2011) and is important, for example, in spoken irony interpretation, as it provides non-linguistic cues, such as tone of voice (Deliens et al., 2017). As previously highlighted, the process of inhibiting one's perspective in favour of acknowledging somebody else's perspective has been associated with ToM (see Apperly, 2012 for an extensive overview; Apperly, Humphreys, Kathirgamanathan, & Samson, 2005; Samson et al., 2010). It remains unclear, however, whether emotion perception skills, such as the ones required for the Karolinska Directed Emotional Faces (KDEF) test, a task used for assessing the recognition of emotions in others and employed in this thesis, would be connected to the same source of cognitive functions involving inhibitory control and recognition of the other person's perspective. Emotion perception could eventually form a separate and distinct cognitive skill unrelated to ToM or be different from other types of ToM skills, not perhaps being subject to cognitive inhibitory processes. Research by Lee et al. (2014) on ToM as a mediator of reasoning and facial emotion recognition found that ToM and analogical reasoning (in this study measured by only one test, the SPM[6]) are independent predictors of facial emotion recognition and that ToM can partially mediate the relationship between analogical reasoning and facial emotion recognition.

[6] The Standard Progressive Matrices (SPM) is a test designed to assess analogical reasoning, a function associated with higher-order executive functions.

The question whether facial emotion recognition is within the ToM scope or not is something the study presented in this chapter may be able to answer.

The on-line perspective-taking task was taken from Samson et al. (2010; see below for a detailed description of the task itself). Samson et al., using neurotypical undergraduate and post-graduate students, found the following results:

- Evidence of intrusions: Slower RTs and higher error rates when the perspectives of the participants and the avatar did not match (i.e. inconsistent trials);
- Evidence of egocentricity: When judging the avatar's perspective when there was a mismatch with the participant's perspective, both RTs and error rates increased;
- Evidence of altercentricity: When judging their own perspective when there was a mismatch with the avatar's perspective, both RTs and error rates increased (though the altercentric intrusion effect was smaller than the egocentric intrusion effect, but only for the RT analyses);

Our aim is to use the same task with patients diagnosed with schizophrenia and neuro-typical controls. We predict that PwS, even after a long-course of second generation anti-psychotic medication, can still display more difficulties in recognising the Other perspective, which would relate to more errors or longer reaction times especially in inconsistent trials that require judgement of the avatar's perspective. This would be in line with findings from Corcoran et al. (1995).

Additionally, we will relate the results obtained in the Perspective-taking task with the components extracted from a new PCA (excluding perspective-taking variables; see below) in order to determine which underlying skills are important while doing this task. By disclosing which cognitive skills relate to participants making fewer mistakes in the task and which makes them react more quickly can help identify cognitive functions connected to perspective-taking and ToM.

3.2. Method

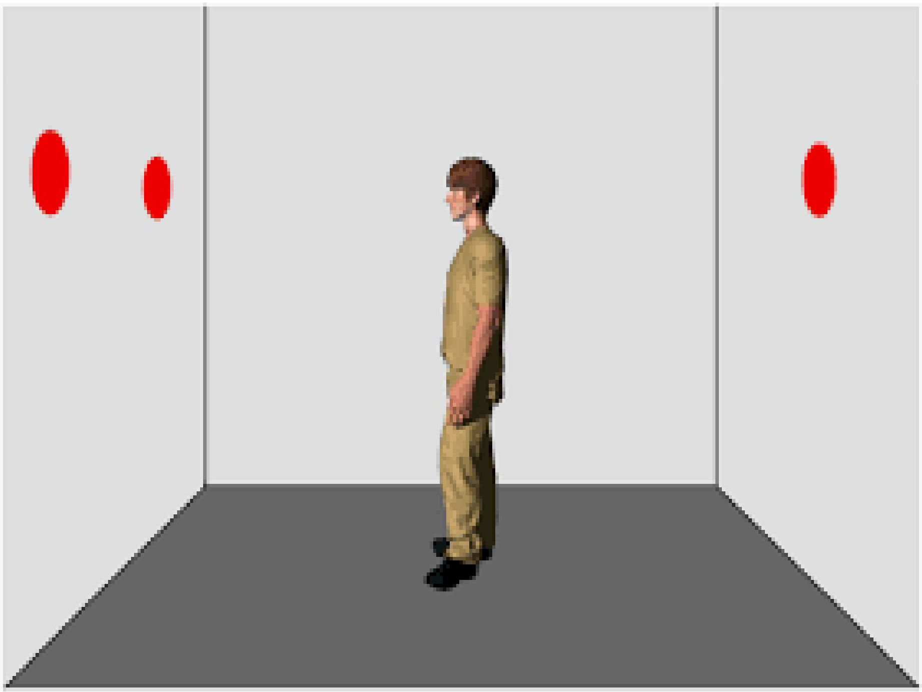
3.2.1. Experiment 1: The Perspective-taking Task

3.2.1.1. Participants

The same participants that took part in test battery 2, (see Chapter 2) participated in the experiment.

3.2.1.2. Stimuli and Procedure

The stimuli were taken from Samson et al. (2010) and showed a picture of a room with a human avatar in it. When looking at the picture, participants could see three walls (back, left and right). These three walls had red discs presented on either one or on two of them. The human avatar was in the centre of the room. The avatar, which could be male (for male participants) or female (for female participants), looked at the left or the right wall. On half of the trials participants and human avatar would share the same perspective, that is, the participant and the human avatar would see the same discs (consistent perspective condition). On the other half of the trials, the human avatar and the participants would not see the same discs, as the avatar would not be able to see the discs on a wall behind them though these were still visible to the participants (inconsistent perspective condition). Although the position of the red discs changed across consistent and inconsistent trials, the position of the human avatar remained permanent.



Following Samson et al.'s (2010) design, this task first presented a fixation cross for 750ms, followed by the word "YOU" or "HE/SHE" (depending whether the participant and avatar were male or female) 500ms later. The word "YOU" or "HE/SHE" remained on the screen for 750ms and it instructed participants to take either their own perspective ("Self" condition) or the avatar's ("Other" condition). Following the perspective instruction, a number appeared on the screen 500ms after the word "YOU" or "HE/SHE". This number could be any digit from zero to three. Again, the number remained on the screen for 750ms and it instructed participants on how many discs they should be certifying on the stimulus presentation. For example: "You" then "3" would appear on the screen and participants had to respond by clicking a mouse button if there were three discs spread on the walls of the room, ignoring the avatar's perspective (see picture above). Using the example above, the following configurations are possible: "You" – "3" = correct; "You" – "2" = incorrect; "He" – "3" = incorrect; "He" – "2" = correct.

Following the perspective and the number of discs instruction, the picture of the room with the avatar in it facing one of the walls appeared on the screen one by one. Participants in our version of the task had 5,000ms[7] to respond to the stimuli by either clicking "YES" (left button) or "NO" (right button) on the mouse. By doing this, they responded that the picture matched the instructions ("YES") or that it did not match either the perspective or the number of discs instructed ("NO").

If participants did not respond to a trial within 5,000ms, the following trial would come up on the screen. On consistent trials, the number of discs matched the number instruction for a given perspective (either "Self" or "Other"), and the correct answer was YES. On inconsistent trials, the number instruction for a given perspective did not match the number of discs that could be seen from that perspective, but could match the number of discs seen from the other perspective, and the correct answer was NO. Inconsistent trials for which the number of discs did not match anybody's perspective

[7] Due to patients taking longer to complete tasks in batteries 1 and 2 and also due to the fact that patients were not so familiar with the mouse, all participants in this version of the Perspective-taking task were given more time (5,000ms) to either press "correct" or "incorrect" rather than the 2,000ms used in Samson et al.

also required a NO answer. These trials worked as fillers in the task and were removed from the results analysis.

The experiment consisted of an initial block of 26 practice trials, followed by four blocks of 48 test trials and four filler trials, totalling 196 test trials and 16 filler trials. A participant saw the same number of Self and Other perspective trials, and the same number of consistent and inconsistent trials. Presentation of the trials was randomized for each participant and presentation of the blocks was counterbalanced.

Participants had to certify their own perspective (48 trials with 24 consistent, matching perspective and 24 inconsistent, mismatching perspective in relation to the avatar's), as well as the avatar's perspective (48 trials with 24 consistent, matching perspective and 24 inconsistent mismatching perspective). The 16 filler trials did not have any discs on the walls. There was a maximum of three successive trials of a given type.

3.2.1.3. Accuracy Analysis Results

We analysed accuracy using the percentage of correct trials. We used a 2 x 2 repeated measures Analysis of Variance (ANOVA) with Consistency (consistent vs. inconsistent) and Perspective (self vs. other) as within-items factors and Group (patients vs. controls) as a between-subjects factor. The accuracy analysis revealed a main effect of Consistency, $F(1, 48) = 20.16$, $p < .001$, with more correct answers for consistent than inconsistent trials, and a significant interaction between Group and Perspective, $F(1, 48) = 6.38$, $p < .05$. Means comparisons indicated that controls made more mistakes when judging the Self perspective (88% vs. 96%; $t(24) = 2.18$, $p < .05$), which was not found for patients (94% vs. 92%; $t(24) = 1.28$, $p > .21$). No further significant differences were found. Further comparisons indicated that patients were marginally more accurate than controls when judging the Self perspective ($t(24) = 1.80$, $p < .09$) but marginally worse than controls when assessing the Other perspective ($t(24) = 1.76$, $p < .10$). Mean accuracy and mean reaction times for the four conditions (consistent self, consistent other, inconsistent self and inconsistent other) can be found in Tables 9 and 10.

Table 9: Accuracy

Group	**Consistent Other**	**Consistent Self**	**Inconsistent Other**	**Inconsistent Self**
Patients	96.2	97.2	86.8	91.2
Controls	98.5	91.7	93.2	84.9

Note: values are in percentages.

Table 10: Reaction times (correct trials)

Group	**Consistent Other**	**Consistent Self**	**Inconsistent Other**	**Inconsistent Self**
Patients	1066 (208)	1112 (205)	1276 (282)	1283 (297)
Controls	901 (254)	973 (373)	1051 (329)	1104 (460)

Note: Reaction times in milliseconds. Standard deviations are in brackets.

3.2.1.4. Accuracy Analysis Discussion

Both groups showed better performance for consistent trials, i.e. when the perspective of the participant and the avatar matched. More interestingly, though, was the finding that controls, but not patients, showed worse performance when judging the Self perspective. This suggests that controls are affected by the "Other" perspective, the altercentric interference, which corroborates the findings of Samson et al. (2010). Hence, the two participant groups seem to have a different baseline when evaluating "Self" and "Other." Patients display errors due to the "Self" perspective (egocentric intrusion), while controls also often make mistakes due to an influence of the "Other" perspective while judging their own "Self" perspective (altercentric intrusion).

3.2.1.5. Response Time Results

Following the same model used for the accuracy data analyses, we used a 2 x 2 two-way repeated measures analysis of variance (ANOVA) using Consistency and Perspective as separate factors. Only trials with correct responses were included in the analyses. We found a main effect of Consistency, $F(1, 46) = 74.28$, $p < .001$, with consistent targets being responded to faster than inconsistent targets, a main effect of Perspective, $F(1, 46) = 4.07$, $p < .05$, with faster RTs for Other-perspective trials, and a main effect of Group, $F(1, 46) = 4.39$, $p < .05$, with controls reacting faster than patients, although none of the interactions approached significance. While the interactions were not significant, the averages (see Table 11) suggested that there might have been differences between the two groups for specific conditions. Indeed, independent samples *t*-tests revealed a significant difference between groups when participants judged the “Other” perspective, with patients significantly slower than controls in consistent, $t(48) = 2.29$, $p < .05$, and inconsistent “Other” trials, $t(48) = 2.55$, $p < .05$. The comparisons for the “Self” conditions did not show significant differences (*p*s > .13).

3.2.1.6. Response Time Results Discussion

Overall, consistent trials were responded to faster than inconsistent ones, and judging the “Other” perspective took somewhat less time than judging the “Self” perspective. Further analyses did show a difference between groups, with patients taking longer to evaluate the “Other” perspective, although these results did not reach significance.

The “altercentric effect”, which was apparent in the accuracy analyses of the controls, did not appear in the RT analyses of correct responses. While the actual RTs for the controls did show that the “Self” perspective took longer to compute than the “Other” perspective (1033ms vs. 977ms), as predicted by the altercentric hypothesis, this was not significant ($p > .13$). The difference between the “Self” and the “Other” perspective was smaller (1176ms vs. 1152ms) among patients than among controls. The difference in RT when judging the Other perspective did not produce a statistic interaction, only a significant difference between groups.

3.3. Principal Component Analysis

We conducted a second principal component analysis (PCA) in R (R Core Team, 2016) without using the variables from the Perspective-taking task to find out how the components from the second battery of tests correlated with the Perspective-taking task variables. A Bartlett's test was run to establish whether there was an identity matrix in the correlation matrix and a KMO test was used to determine the degree of common variance in the data and suitability for a PCA analysis, a varimax rotation was applied. Four components accounting for 77% of the variance were retained based on Kaiser's Rule. We kept the same component names from the previous PCA analysis, as their loadings were very similar.

The principal component analysis extracted nine components from the data set, with eigenvalues ranging from -0.28 to 3.19. Standardised loadings (pattern matrix) were based upon the correlation matrix within the data set. The first four components accounted for 77% of the variance and were retained as their loadings were greater than 1, except for Component 4, which presented a loading of 0.97. These four components appear in order of variance accounted for, as shown in Table 13. Residuals statistics revealed a root means squared residual of 0.08, which was equal to the 0.08 threshold. The proportion of absolute residuals was 0.05, equal to the threshold. Table 11 displays the results for the nine components and Table 12 displays the results for the four components accounting for 77% of the variance that were kept for the analysis.

As was the case for the original PCA, for this PCA analysis and the correlations below, we only had 21 control participants compared to 25 in the analyses above.

Table 11: Principal Component Analysis Excluding Perspective-Taking - Results

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
SS loadings	3.19	1.65	1.11	0.97	0.67	0.59	0.34	0.31	0.17
Proportion Var	0.35	0.18	0.12	0.11	0.07	0.07	0.04	0.03	0.02
Cumulative Var	0.35	0.54	0.66	0.77	0.84	0.91	0.95	0.98	1.00
Proportion Explained	0.35	0.18	0.12	0.11	0.07	0.07	0.04	0.03	0.02
Cumulative Proportion	0.35	0.54	0.66	0.77	0.84	0.91	0.95	0.98	1.00

Table 12: Principal Component Analysis Excluding Perspective-Taking: Four Factors with Loading Values

Component 1: Flexibility and Working Memory		**Component 2: Difficulties in Mentalising and in Cognitive Control**		**Component 3: Facial Emotion Recognition**		**Component 4: Hinting Comprehension**	
Elevator Counting with Reversal	0.89	Degree of Difficulty in the Hinting Task	0.87	KDEF	0.93	Hinting Task Score	0.95
TEA Elevator 1	0.87	Degree of Difficulty in	0.84	Elevator Counting	0.51		

		the Cognitive Control Task		with Distraction			
TEA Elevator 2	0.70	Control and Flexibility	-0.67	Cognitive Control Task	0.35		
		Elevator Counting with Distraction	-0.44				
% of variance	0.25	% of variance	0.24	% of variance	0.15	% of variance	0.13
Cumulative variance	0.25	Cumulative variance	0.49	Cumulative variance	0.64	Cumulative variance	0.77

All components extracted in the second PCA analysis were very similar to the previous PCA analysis, except that this time the Facial Emotion Recognition component explained slightly more of the variance than the Hinting Comprehension component (which were equal in the original PCA, see Chapter 2).

3.3.1 Correlations between the Perspective-taking Task and the second PCA

To find out how the cognitive, mentalising (Hinting Task) and facial emotion recognition skills extracted related to perspective-taking, we ran separate correlation analyses for the accuracy and the RT data for each group. Results for the accuracy correlations are presented in Table 13[8] and results for the reaction times correlations are presented in Table 14[9].

Table 13: Correlations between errors in perspective-taking and the second PCA

		Flexibility and Working Memory	Difficulties in Mentalising and Cognitive Control	Facial Emotion Recognition	Hinting Comprehension
Patients	Consistent Other	*r* = -.365	*r* = -.119	*r* = .111	***r* = -.412***
	Consistent Self	*r* = -.356	*r* = -.207	*r* = .004	***r* = -.480***
	Inconsistent Other	*r* = -.350	*r* = -.184	*r* = -.170	***r* = -.454***
	Inconsistent Self	*r* = -.360	*r* = -.125	*r* = -.189	***r* = -.480***
Controls	Consistent Other	*r* = -.327	*r* = -.180	*r* = -.374	*r* = -.294
	Consistent Self	*r* = .360	***r* = .565****	*r* = .014	*r* = .354

[8] Correlation results presented in the table are uncorrected for multiple comparisons due to the relatively small number of participants. Results shown in Table 15 are exploratory and we didn't want to miss trends that could be present in the data by being overly strict. After Bonferroni corrections, results for the control group remained significant.

[9] Like in Table 15, Table 16 correlation results are presented uncorrected for multiple comparisons for the same reasons reported above. No reaction time correlations remained significant after running Bonferroni corrections.

	Inconsistent Other	*r* = .009	*r* = 102	***r* = -.595****	*r* = -.294
	Inconsistent Self	*r* = .129	*r* = -.178	*r* = .091	*r* = -.013

Note: Significance level is indicated by stars: **p* <.05; ***p* < .01; ****p* < .001.

Table 14: Correlations between reaction time in perspective-taking and the second PCA

		Flexibility and Working Memory	Difficulties in Mentalising and Cognitive Control	Facial Emotion Recognition	Hinting Comprehension
Patients	Consistent Other	*r* = -.116	*r* = .295	*r* = -.064	*r* = -.358
	Consistent Self	*r* = -.058	*r* = .318	*r* = .084	*r* = -.363
	Inconsistent Other	*r* = -.061	***r* = .445***	*r* = -.087	***r* = -.411***
	Inconsistent Self	*r* = -.104	***r* = .402***	*r* = .040	*r* = -.343
Controls	Consistent Other	*r* = -.286	*r* = .248	*r* = -.151	*r* = .265
	Consistent Self	*r* = -.378	*r* = .405	*r* = -.047	*r* = .246
	Inconsistent Other	*r* = -.188	*r* = .215	*r* = -.020	*r* = .137

Inconsistent Self	r = -.363	r = .261	r = -.015	r = .181

Note: Significance level is indicated by stars: *p <.05; **p < .01; ***p < .001.

3.3.2. Second Principal Component Analysis Discussion

Results from the second PCA and their correlations with errors in perspective taking confirmed results obtained from the first PCA in the sense that perspective-taking variables appeared inversely (negatively) connected with Hinting Comprehension, except that in this case we were able to determine this to be true among patients, not controls. Patients who had more effective hinting comprehension skills made fewer errors when judging both the "Self" and "Other" perspectives.

For the controls, accuracy correlation results revealed that more perspective-taking errors in the Consistent Self condition were related to more difficulties in mentalising and cognitive control. Hence, these results suggest that more effective mentalising skills can have a positive impact on perspective taking. The results from the control group also indicated that Facial Emotion Recognition was negatively correlated with errors in judging the "Other" perspective in inconsistent trials in the Perspective-taking task. This suggests that more effective facial emotion recognition skills can be related to fewer errors in judging a different person's perspective in inconsistent trials.

Reaction time correlation analysis showed that longer reaction time for patients related to difficulties in mentalising and in cognitive control for patients. Results for controls were only borderline significant for the "Consistent Self" condition. For patients, more effective hinting comprehension skills related to shorter reaction times in judging inconsistent other trials, which agrees with the findings from the accuracy analysis, where patients who had more effective hinting comprehension skills tended to make fewer mistakes when judging inconsistent other trials. It seems that mentalising skills help participants do better in perspective-taking, which only reinforces the connection between these two tasks and between these two tasks and ToM.

3.4. Experiment 2: Facial Emotion Recognition

Another cognitive skill often associated with theory of mind is facial emotion recognition (Bora, Yucel, Pantelis, 2009; Kohler et al., 2010). Facial emotion recognition is the ability to give a meaning to facial expressions coming from interlocutors in everyday conversation. In fact, a great deal of human spoken communication in common interactions relies on nonverbal signs, such as facial emotion expression (Knapp, Hall & Horgan, 2014). Being able to give a meaning to facial expressions is a very important skill for anyone to be successful in daily social interactions and is a primary communicative tool that most humans manage to acquire.

Irony and sarcasm rely greatly on prosodic elements such as pitch, stress and volume (Ekman, O'Sullivan, Friesen & Schererk, 1991) and facial expressions seem to accompany prosodic features in everyday communication. We can then say that the ability to interpret prosodic features and facial expressions is core to human understanding of one another.

Research so far has reported that in schizophrenia facial emotion recognition is impaired (for an overview, see Kohler et al, 2009). A large majority of these studies, however, has tested inpatients. The present study aims to shed a light on facial emotion recognition in outpatients who have been on medication for more than ten years (*M* = 16.37, ME = 12.5) and who had not received any other psychiatric diagnosis besides schizophrenia, not even schizoaffective disorder, as they were checked for diagnosis accuracy with the SCID and the PANSS (see Chapter 2). Besides being on anti-psychotics, three of the patients were either on anti-depressants or on low doses of anxiolytics as well.

Asgharpour et al. (2015), in an eye-tracking study, found that patients diagnosed with schizophrenia had a smaller number of eye-fixations on faces in general, despite the emotions the photographs showed. However, in the case of Asgharpour et al.'s (2015) study, patients had a 500ms threshold fixation time in each image that could not have been enough for patients, who tend to be slower. Akbarfahimi et al. (2013) in an ERP study found that patients diagnosed with schizophrenia displayed longer latencies and reduced N170 peaks when looking at happy, fearful and neutral faces when compared to controls.

Up to 2009, Kohler et al. (2010) identified 86 studies on facial emotion perception in schizophrenia and many of them reported a large impairment in emotion perception in patients. Although these studies involved a vast range of clinical and socio-demographic characteristics, they tend to point to a general emotion recognition impairment that the present study aims to investigate in patients who have been on medication for a long time and are in the process of remittance.

Since facial emotion recognition is a basic tool acquired from people's first social experiences, it is possible that a patient can more easily employ it after having gone through a schizophrenic episode and, medicated and/or in psychological therapy, being on the route to recovery. In this case, to be able to use emotion perception skills would represent a positive prospective for patients and it could enhance the quality of their daily interactions. In addition, if a patient can retrieve emotion recognition skills after a schizophrenic episode, it could be a sign of a more favourable clinical outcome, at least as far as social cognition skills are concerned.

We hypothesise that people in remittance from schizophrenia would have recovered their facial emotion recognition skills because they would be functioning closer to normality at a psychosocial level. In this sense, outpatients diagnosed a long time ago who have been on medication since the first episode, like the patients who took part in the present study, would tend to perform more effectively if compared, for example, to inpatients, who are in the middle of a schizophrenic episode. However, we did not test inpatients, and our research question is whether outpatients will perform as well as controls.

3.4.1. Participants

The participants for the Karolinska Directed Emotional Faces Test (KDEF) were the same used in the Perspective-taking task, except that in the KDEF there were 27 participants in the patient group and 29 participants in the control group. Because the KDEF was one of the first tests administered in the research, participants had not yet dropped out or discontinued their participation in the study, so we could count on more participants for both groups.

One participant from the patient group reported a high score in the Levenson Self-Report Psychopathy Scale, a screening test for this study, and because his results on the KDEF were clear outliers, we excluded him from the analysis.

3.4.2. Stimuli and Procedure

A shortened version of the Karolinska Directed Emotional Faces Test (KDEF), Lundqvist et al. (1998), was used in this study. It had 70 trials that consisted of 70 different photographs of people displaying one of seven different emotional expressions: fear, disgust, happiness, anger, neutrality, sadness and surprise. These seven basic emotional expressions appeared in five different face angles each (full left, full right, half left, half right and straight). Male and female photographs emerged equally across the trials.

Participants saw a photograph on the computer screen containing either a male or a female model acting one type of emotional expression in an angle. The emotional expression options for participants to choose from (angry, afraid, disgusted, happy, neutral, sad and surprised) appeared on the right-hand side of the computer screen. Participants then saw the picture in the centre together with the options. To test participants' abilities to distinguish emotions even in not so favourable or clear picture contexts, KDEF test photographs are not completely clear or sharp. After participants looked at the pictures and analysed the emotional expression options to choose from, the experimenter would then ask participants to say which emotional expression they thought would best describe the photograph they saw on the computer screen.

We did not track the time in the KDEF test and participants had as much time as they needed to analyse the options and respond. After responding, participants hit the spacebar to proceed to the next photograph. They responded to 70 trials and the experimenter ticked the options each participant chose. We computed results according to the number of correct answers given by each participant.

Table 15: KDEF results by group – Number of mistakes in percentages.

Group	Surprised	Sad	Angry	Afraid	Happy	Disgusted	Neutral
Patient (27)	41(1.8)	21(2.2)	23(2.1)	7.5(.594)	4(.742)	8(1.05)	41(2.54)
Control (29)	38(2.1)	23(2.0)	27(1.8)	13(1.63)	2(.412)	12(1.48)	36(2.87)

Note: Standard deviation between brackets

3.4.3. KDEF Test Results

We ran a 7 (Emotion Type) x 2 (Group) repeated measures ANOVA with the KDEF scores collected for both groups (see detailed table in the Appendix). There was a significant effect of Emotion Type: $F(6) = 34.104$, $p < .001$. There were no overall differences between the two groups ($F(1) = .105$, $p > 1$), nor did we observe a significant interaction ($F(1) = .002$, $p < 1$).

The effect of condition in the repeated measures ANOVA was expected, as participants behaved differently when judging the different emotions. Some emotions were easier for both groups and others more difficult. Overall, patients and controls' scores were very similar in this task, with patients' mean accuracy scores being 54 (77% accuracy) and controls' 56 out of 70 (80% accuracy). Moreover, no differences between groups in any emotion recognition were found in independent samples *t*-tests (all *p*s > .158).

Since Laroi and Raballo (2010) found that participants made more errors when judging fear ("afraid") than when judging happiness, we compared the accuracy on these two emotions in our sample as well. Our data showed a similar difference: $t(55) = 4.2$, $p < .001$ (fear: 10.3% mistakes, happiness: 3.0% mistakes). The fact that happiness is much easier to be recognised than sadness in both groups suggests that the recognition of sadness is not as straightforward as happiness. It should be noted that there were many other differences in accuracy between the different emotions. However, as this is not relevant for our research question, we will not report these. Details of all emotion comparisons can be found in Appendix B.

3.4.4. KDEF Test Results Discussion

Results above indicate that, unlike Laroi, Fonteneau, Mourad and Raballo (2010), this experiment found no significant differences in facial emotion recognition between PwS and controls. The fact that most of the patients used in this study were people who had been on medication for more than 10 years could have had a positive impact on the KDEF results, as facial emotion recognition impairments are usually more severe in the acute phase of the illness (Bora et al., 2009). In addition, Laroi et al. (2010) used inpatients, not outpatients, and inpatients often present a more acute form of the disorder when compared to outpatients.

In addition, 11 out of 25 patients in this experiment were in partial remittance, a fact that we must take into consideration if results obtained in this study are to be compared with results obtained by other studies (e.g. Laroi et al., 2010). Finally, since we did not track time in this task and patients had as much time as they needed to be able to choose one facial emotion expression, we cannot be certain about patients' facial emotion recognition speed. We can only say that accuracy was not significantly different between groups.

The suggestion by Kohler et al. (2010) that facial emotion recognition impairment could be a trait of schizophrenia is not supported by this study. Differences in patients' profiles, their status as inpatients and outpatients and their social integration in the community (12 participants in this study worked or were doing voluntary work and had some kind of integration in the community) apparently can increase or decrease the group score in the task.

Our study is the first study we know of that tested facial emotion recognition in patients in remission of schizophrenia and patients who have been on second-generation anti-psychotic medication for a long time. The finding of the present study adds information about the effects of long-term basis second-generation anti-psychotic medication on facial emotion recognition. It appears that patients can perform well on facial emotion recognition if they sustain treatment with second generation anti-psychotic medication, and perform markedly better than inpatients (Bora et al., 2009; Laroi et al., 2010).

However, when testing facial emotion recognition, studies in the future must take into consideration the necessity of eliminating participants who have a high score in psychopathy scales. For the present study, the one participant we eliminated for this reason from the analyses made an inordinate number of mistakes (43). The patient group mean was much lower than that (16).

Another aspect that requires attention from researchers is that the fact that people can recognise facial emotions does not necessarily imply that they can acknowledge the "Other" point-of-view. Recognising facial emotions and acknowledging the "Other" point-of-view seem to be relatively independent cognitive functions (see Chapter 2). At least, the fact that patients and controls did display similar results in the KDEF, unlike results from the Perspective-taking task, suggests that recognition of facial emotions and recognition of the "Other" and "Self" perspectives can involve relatively autonomous operations. It is possible, judging from the results of the tasks described so far, that the recognition of "Self" and "Other" perspectives could require the presence of more complex neural operations.

3.5. Experiment 3: The Hinting Task

Corcoran et al. (1995) were the first to propose the Hinting Task as a test to measure the ability to infer what different people mean in common daily utterances when they choose to use hints and implicatures to communicate an idea. The test involves identifying what the character really meant when he/she used an indirect form of communication, rather than a simple, straightforward one.

The Hinting Task presents 10 short stories that the experimenter reads aloud to each participant. At the end of each short story, a character drops a hint or implies something about the situation described in the story. The experimenter than asks, "What does the character [normally naming the character] really mean when he/she says this?" Each participant then must answer according to the context and according to the character's intention, which becomes clear in the story. If participants are not able to give a correct answer the first time they answer the question, the experimenter proceeds to the second hint and asks a direct question, such as, "What does Jessica want Max to do?" If participants need to listen to the story again and require so, the experimenter reads it again.

In this study, differently from Corcoran et al. (1995), and unlike all other studies that used the Hinting Task, there are two other measurements being recorded besides accuracy, which are Time and Degree of Difficulty of the Task (on a scale from 1 to 10). Time is an important measurement in the Hinting Task because it can tell a lot about how participants react to the task and it also can tell you about how straightforward the hints sounded to participants. The Degree of Difficulty estimate is useful because it can show how easy or difficult participants perceived the task. Accuracy alone does not tell everything about how participants felt the task and how they reacted to it.

For example, a participant can give the experimenter a correct answer, either after the first or the second hint, but that participant could have taken a lot more time than typical. This fact could be an indication that the knowledge of what is going on in the other person's mind in the story, the mentalising skill, is not available for that participant in an on-line fashion. Imagine, for example, in an actual social interaction, the implications of not having a theory of mind available on-line. The person talking to the one who is slower to understand what she/he is hinting can give the impression that slowness is a sign that the person they are talking to is not following. The scores in themselves do not give us precious pieces of information that we can access by measuring Time and Degree of Difficulty and this is the reason why these measurements were included in this study. It is possible that patients will take longer to do the Hinting Task and they find it more difficult as well.

Corcoran et al. (1995) first used the Hinting Task to test patients' ability to infer implicatures and indirect meanings in specific speech contexts. The experiment had a control group of 44 people and a patient group of 55 people who were divided into six separate groups according to their symptoms (negative features, paranoid symptoms, incoherence, passivity experiences, other symptoms and remission). Most of the participants used in the study were inpatients on psychiatric wards.

The difference Corcoran et al. (1995) found between the two groups was significant, $t(97) = 4.16$, $p < .001$, and they found a correlation between the Hinting Task score and estimated IQ in the patient group, which was not found in the control group. The authors suggested that patients were relying on general intellectual abilities to perform a social task that seemed to have no reliance on intellectual abilities for controls. They also found that this could be taken as evidence for cognitive deficits among some of the patients they tested. Overall, patients who did not present any symptoms (N = 8) had a normal performance on the Hinting Task. The results Corcoran et al. (1995) obtained support the idea that patients had difficulties in inferring what the intentions of other people were.

Later, Corcoran and Frith (2003) used the Hinting Task, The Theory of Mind Stories test and several memory tests to investigate the relationship between autobiographical memory and Theory of Mind in schizophrenia (they considered the Hinting Task as a ToM task). Their findings suggested that patients have a ToM deficit and an impoverished autobiographical memory retrieval, and they reported a connection between hint comprehension and memory accessibility with approximately

44% of the variance on the Hinting task being accounted for by the ability to recollect memories. Again, they found that patients in remission (N = 15) performed similarly controls.

In the present study, we did not use autobiographical memory measures. We wanted to test whether our patients indeed showed a deficiency on the hinting measure. In addition, given that the sample of patients in remission was relatively small in Corcoran and colleagues' studies, we wanted to confirm their findings of normal performance for patients in remission. Finally, we wanted to extend the research by not only looking at accuracy but also at task difficulty and time take to complete the task.

3.5.1. Participants

Participants who took part in the Hinting Task were the same as for the KDEF, with the same number of participants. Results from the participant from the patient group who had reported a high score in the Levenson Self-Report Psychopathy Scale had been excluded from the experiment.

3.5.2. Stimuli and Procedure

The experimenter read the instructions of the test aloud to each participant and then read 10 short stories of one paragraph each. Participants answered the question posed after the first hint. If participants did not give a correct answer to the first question, then the experimenter would read the second hint and ask another question.

If participants still did not give a correct answer to the second hint, then they would receive zero (0) points in the general score for that story. If participants got the second hint answer right, then they would receive one point (1) for that story and if participants had given a correct answer in the first hint, then they would receive two points (2) in the general score.

The experimenter tracked the time used by each participant to do the Hinting Task with a stopwatch, which was set as soon as she started reading the first story. As soon as participants finished answering the last question of the last story, the stopwatch would be paused. At the end of the task, the experimenter asked participants how difficult they had found the task on a scale from 1 to 10, with 1 being very, very easy and 10 very, very difficult. Participants would then give their Degree of Difficulty score to the task.

3.5.3. Hinting Task Results

Results for the different measures can be found in Table 16. Independent samples *t*-tests showed significant differences in all three measurements, Hinting Task Score: $t(48) = 2.132$, $p < .05$; Time: $t(48) = 3.683$, $p = .001$; and Degree of Difficulty: $t(48) = 3.559$, $p = .001$.

Table 16: Hinting Task results

Measurement		Means
Hinting Task Score (Maximum score = 20)		
	Patients	14.5 (2.8)
	Controls	16.0 (2.4)
Hinting Task Time (seconds)		
	Patients	450.4 (105.6)
	Controls	353.7 (78.0)
Degree of Difficulty in the Hinting Task (1-10)		
	Patients	3.72 (1.9)
	Controls	2.22 (1.0)

Note: Standard deviations in brackets

We did not find a significant difference between patients in partial remission *(N* = 11) and controls for their hinting score: $t(34) = .494$, $p = .625$ (Mpatients = 15.64, SD = 2.01; Mcontrols = 16.04, SD = 2.35). Similarly, for the time measure, we did not find a difference between patients in partial remission, (M = 402, SD = 102) and controls (M = 354, SD = 78.03), $t(34) = 1.559$, $p = .128$. However, we found a significant difference for the Degree of Difficulty measure between patients in partial remission (M = 4, SD = 1.94) and controls (M = 2.22, SD = 1.0), $t(34) = 3.280$, $p = .002$, with patients in partial remission finding the Hinting Task significantly more difficult than controls.

Overall, there were significant differences between the patient and control group in the Hinting Task. It became clear too that the results obtained in the variables "Time" and "Degree of Difficulty of the Test" confirm our hypotheses that patients may need more time to do the task and that they may find it more difficult. Even when patients take approximately the same time to do the tasks as neurotypical controls, as is the case for patients in partial remittance, they still find it more taxing than controls.

3.5.4. Hinting Task Results Discussion

Although most of the patients used in this study had been on second- generation anti-psychotic medication for more than 10 years and, at the time of testing, a few of them were even doing voluntary work and partially integrated in the community, the ones who still presented positive/negative symptomatology still performed more poorly in the Hinting Task when compared to controls.

Patients classified as in partial remission according to the SCID results had similar scores to controls, which supports Corcoran et al. (1995). Although there was no significant difference in Time between patients in partial remission and controls, there was still a significant difference in Degree of Difficulty, which means that patients in remission still found the Hinting Task significantly more taxing than controls.

Overall, patients took significantly longer to do the Hinting Task and they found it significantly more difficult than controls, although they did not find the task extremely difficult, giving it a mean score of 4 in difficulty on a scale from 1 to 10.

The fact that patients and controls don't find the Hinting Task equally easy suggests that ToM for patients is still taxing, even though the patients used in this study have been on second generation anti-psychotic medication for more than 10 years.

The difference in Time between groups suggests that mentalising skills may not be available for patients in an on-line fashion, and, in an actual social interaction, the time gap in picking up the hints can somehow indicate that the interlocutor is simply not following the conversation. Again, time used to perform the tasks is something that we must consider when analysing schizophrenia data because it is a sign that adjustments needed for the mentalising processes to take place can be too slow and social interactions in the real world, either in the workplace or in a more familiar context, require more effective skills. Nevertheless, the fact that patients in remission did not present a significant difference in relation to controls in Time suggests that the presence of positive/negative symptomatology increases the time used to do the task and makes cognitive adjustments more taxing.

The difference in degree of difficulty between patients and controls could be an indication that patients rely on other complex cognitive operations to be able to interpret hints. For patients, interpreting the hints in the task was not as straightforward as it was for controls; in fact, it was more taxing, and this also becomes apparent when we consider that patients in partial remission still found the Hinting Task significantly more difficult than controls.

Results obtained in this study confirm previous ones (Corcoran & Frith, 2003; Corcoran et al., 1995; Pickup & Frith, 2001). The fact that 14 patients out of 25 who participated in this study still presented positive or negative symptomatology, either at a subthreshold or at a threshold level, could have decreased patient group results in the task.

Results obtained for the Hinting Task in this experiment cannot confirm Herold et al.'s (2002) suggestion that, in schizophrenia, Theory of Mind impairment would be a trait that is present even in the remittance stage of the illness. Although we only had 11 participants in remittance stage, their results did not show a significant difference in relation to controls, except in the variable Degree of Difficulty. We can say that they find it more difficult, but we cannot say that the impairment persists in the remittance stage.

3.6. General Discussion

In general, results from the Perspective-taking task supported Samson et al. (2010) in the sense that controls made more mistakes when judging the "Self" perspective when compared to the "Other" perspective. This means that there was in fact an intrusion of the "Other" perspective when controls were judging their own perspective, which could suggest that patients might not be as tuned in to the "Other" perspective as controls, although this effect did not produce more errors for patients when judging the "Other" perspective, possibly only making the judgement of the "Other" perspective more difficult for patients.

In general, reaction times corroborated results for accuracy in the Perspective-taking task, as patients were significantly slower than controls when evaluating the "Other" perspective. This slowness became even more apparent when trials were inconsistent, although it was present for both consistent and inconsistent trials.

Inconsistent trials required sharper tuning skills as the participant and avatar did not share the same perspective when looking at the discs on the wall, which we found can be more difficult to patients. These findings highlight the presence of a “self-reference effect” for patients, indicating that adjustments to the “Other” point-of-view can be challenging for patients.

Results from the first PCA (see Chapter 2) indicated that perspective-taking (error analysis consistent and inconsistent other) was inversely correlated in Component 1 with flexibility and working memory, suggesting that more effective flexibility of thought and working memory can improve accuracy in judging the “Other” perspective. The same pattern of results was found for Component 4 (Hinting Comprehension), indicating that more effective mentalising skills can also improve accuracy in judging “Other” trials, both consistent and inconsistent. The pattern found in Component 4 only reinforces that both the Perspective-taking and the Hinting Comprehension tests tap into ToM skills.

Results from the second PCA and their correlations with the perspective-taking variables confirmed results obtained from the first PCA. We found again an inverse correlation between perspective-taking variables and Hinting Comprehension, although in the second PCA this was true only for patients, not for controls. Patients who had more effective hinting comprehension (mentalising) skills made fewer errors when judging “Self” and “Other” perspective. Results for the control group revealed that errors in perspective-taking when judging the “self” perspective related to more difficulties in mentalising and in cognitive control. Apparently, judging from these results, mentalising and cognitive control are relevant cognitive functions for ToM. Additionally, more effective facial emotion recognition among controls related to fewer errors in judging the “Other” perspective (inconsistent trials), which suggests that good facial emotion recognition skills can contribute to a more effective judgment of the “Other” perspective.

The KDEF experiment results revealed no significant differences in facial emotion recognition between PwS and controls. When evaluating the results, we must consider that most of the patients used in this study were people who had been on medication for more than 10 years. In this case, we can speculate that medication can have a positive impact on facial emotion recognition for PwS, as other studies (Bora et al., 2009; Laroi et al., 2010) with inpatients, probably in more severe phases of the illness, did not report similar results.

In addition, because facial emotion recognition was in a separate uncorrelated component in relation to perspective-taking and mentalising skills in both PCAs (see Chapter 2) and did not appear either positively or negatively correlated with perspective-taking in any component, unlike mentalising skills tested in the Hinting Task, we cannot say that facial emotion recognition underlies the same type of ToM processing. In fact, considering the results, it is possible that they are related, but independent cognitive functions, involving relatively autonomous operations, although results showed that facial emotion recognition helped increase effectiveness of perspective-taking skills when judging the “Other” perspective in inconsistent trials.

Results from the Hinting Task, which revealed significant differences between patients and controls in all measures tested, score, time and degree of difficulty, suggest that mentalising skills are generally still impaired for PwS, except for patients in partial remission, whose results were compatible with neurotypical controls. Patients in partial remission, however, still found the Hinting Task more difficult than neurotypical controls, which suggests that although mentalising skills can be used by patients in remission, they are still more challenging for these patients than for neurotypical controls. It seems that although the impairment is no longer there, some difficulty in relation to mentalising still remains.

The present study does not support the idea that an impairment in facial emotion recognition could be a trait of schizophrenia (Kohler et al., 2009). On the contrary, results from this study suggest that facial emotion recognition can be working effectively for patients who have been on medication for a long time and are relatively integrated in the community, like the ones who took part in this study.

Chapter 4

IRONY PROCESSING STUDY

4.1. Introduction

Language phenomena related to schizophrenia are a source of neuroscientific curiosity (Kuperberg, 2010a; 2010b; Kuperberg & Heckers, 2000; Reichenberg et al., 2009) because having a broader perspective of the mechanisms underlying cognitive functioning in schizophrenia can be valuable for improving the current understanding of the factors underpinning some of the symptoms related to the disorder. In language production, patients with schizophrenia (PwS) can sometimes display difficulties in maintaining an organised discourse plan (thought disorder) and sometimes their speech also contains neologisms or unintelligible utterances (schizophasia) (Kuperberg, McGuire & David, 1998). The manifestations of thought disorder can be seen in poor speech content (inability to transmit enough information), in a difficulty or inability to stick to the intended topic, and in a general discourse illogicality that makes the person's speech sound more like a chain of incoherent associations.

Figurative language processing deficits were first identified in patients diagnosed with schizophrenia in the early twentieth century (Benjamin, 1944; Finckh, 1906). Today, proverb interpretation, which involves figurative language processing, is used in the Positive and Negative Syndrome Scale (PANSS), a scale measuring the severity of symptoms in schizophrenia. The fact that proverb interpretation is used in the PANSS suggests that inaccuracies in figurative language processing can be a valuable tool to measure abstract reasoning and thought disorder levels in patients diagnosed with schizophrenia. It also suggests that language processing measures can add valuable insights into cognitive functioning in schizophrenia. Since proverb interpretation is also part of the Comprehension sub-test of the WAIS-IV, it can be argued that the ability to build meta-representations is a sign of neuro-typical IQ development.

Some studies on language processing in schizophrenia not involving figurativeness (David, Kuperberg & McGuire, 1998; Kuperberg &, Heckers, 2000) found that patients who displayed thought disorder were less sensitive to violations of the semantic context than patients who did not display thought disorder. These studies highlight that the severity of thought disorder could influence a patient's sensitivity to context violations, semantic incongruity and anomaly.

Other studies (e.g. Hoff et al., 1999) reported deficits in cognitive functioning and verbal working memory among patients diagnosed with schizophrenia in the first 2 to 5 years of the illness and Wood et al. (2007) speculated that working memory impairments arose when complex brain interconnections were necessary for patients in their first episode of psychosis to perform language tasks. Reading comprehension impairments were also found in teenagers who later developed schizophrenia (Fuller et al., 2002; Vourdas et al., 2003).

Overall, several studies (Kuperberg, 2010a; 2010b; Lee & Park, 2005) have demonstrated that PwS display deficits in cognition, especially in working memory and executive functions, and that positive thought disorder correlates with low scores in other cognitive tasks. Kerns and Berenbaum (2002) also reported that patients afflicted by thought disorder had a low performance in tests that assessed executive functions. Other studies (Kuperberg, 2010a; 2010b) suggest that executive functions and working memory could play a role in context construction and context information use.

Research in figurative language processing in schizophrenia has shown that patients diagnosed with schizophrenia display a preference for concrete over figurative interpretations (Brune & Bodenstein, 2005; Kiang, Kutas, Light & Braff, 2008). Langdon, Coultheart, Ward and Catts (2002) reported that poor metaphor and poor irony understanding made significant contributions to the discrimination between PwS and neurotypical controls. It has also been reported that PwS are less efficient in integrating the semantic context of all sentences, both figurative and literal, and that PwS more typically chose literal interpretations of figurative idioms in idiom interpretation tasks when compared to controls (e.g. Iakimova, Passerieux & Hardy-Bayle, 2006; Iakimova, Passerieux, Laurent, & Hardy-Bayle, 2005; Kircher, Leube, Erb, Grodd, & Rapp, 2007).

Other studies (Ditman, & Kuperberg, 2010; Sitnikova, Salisbury, Kuperberg & Holcomb 2002; Titone, Levy, & Holzman, 2000) indicated that, when building up the meaning of sentences in homonym ambiguity tasks[10], patients diagnosed with schizophrenia were more dependent on semantic associations between individual words rather than the whole sentence context, which could be a relevant deficit for irony processing because for an irony to make sense, it is required that the whole context is processed by the speaker.

As far as context comprehension is concerned, it has been found that contextual familiarity enhances a patient's ability to extract the meaning from a non-figurative text (Ditman & Kuperberg, 2010; Sitnikova, Perrone, Goff & Kuperberg, 2010; Sitnikova, Salisbury, Kuperberg, & Holcomb, 2002). These authors reported that, in

[10] "*Diving was forbidden from the bridge/The guests played bridge… because the river had rocks in it.*" Unlike PwS, neuro-typical individuals detected the contextual anomaly when the inappropriate initial sentence was used, which was highlighted by a non-attenuated N400 effect (Sitnikova et al., 2002).

familiar contexts, patients have been able to display a more accurate understanding of the events in the text, while in unfamiliar contexts, this did not happen as frequently. Contextual processing, both from the linguistic and the extra-linguistic context, could be key in irony recognition too, and studies in context processing in schizophrenia suggest that global context may not be fully grasped (David et al. 1998; Kuperberg & Heckers, 2000).

The intent of communicating something that is not literally expressed can be crucial to language interaction in daily life. The meaning of an utterance often intermingles with the non-linguistic context. The knowledge of this extra-linguistic context is fundamental for a person to be able to convey and understand meanings beyond the literality of a certain single semantic level. Deficits in the ability to build meta-representations and processing figurativeness can then become an obstacle for patients diagnosed with schizophrenia to be able to understand other people's meanings or intentions.

4.1.1 Models of Irony Processing

There are several models of irony processing, three of which we will discuss here. The first one, the Standard Pragmatic Model (Grice, 1975; Searle, 1979, 1983), proposes that ironic interpretation happens in stages, with the literal interpretation taking precedence over the figurative one. The ironic meaning will only be computed if the speaker identifies a mismatch between the literal meaning and the context in which the irony is embedded. The speaker then, acknowledging the mismatch and inappropriateness of the literal meaning for the context, interprets the ironic meaning accurately. In the Standard Pragmatic Model, the ironic meaning is always the opposite meaning of the literal utterance. Ironic meaning processing in the Standard Pragmatic Model is more taxing than literal meaning processing because it involves two stages of cognitive operations.

The second model is the Direct Access Model, which proposes that appropriate contexts induce early appropriate lexical processing (Gibbs, 1986, Gibbs, O'Brian, & Doolittle, 1995). Figurative meaning in this model is accessed directly, without any further cognitive operations. In this model, we would process ironic meanings just like we process literal meanings. Unfamiliarity does not present a problem for this model, as it claims that the appropriate context is enough for the speaker to jump straight to the figurative interpretation of the utterance, with no need for additional cognitive processes to take place.

The third model is the Graded Salience Hypothesis (Giora, 1997, 2003; Giora & Fein, 1999). In this model, only the salient figurative meanings are accessed directly, just like when we process literal meanings. All novel figurative meanings would require additional inferential operations, making them more taxing than salient figurative meanings. The Graded Salience Hypothesis model does not claim that the ironic meaning replaces the literal one at a later stage, but rather that both meanings are maintained ('retention hypothesis'), so that the identification of the mismatch in the context can take place (Giora, 2003, p. 72).

Filik et al. (2014) reported eye-tracking and ERP results for familiar and unfamiliar ironies that supported the Graded Salience Hypothesis, as they found no differences in reading times for familiar ironies and a processing cost for unfamiliar ironies. Results from their ERP experiment reinforced the findings from their eye-tracking experiment, revealing a tendency for a more negative centroparietal N400 waveform for unfamiliar ironies, not familiar ironies. In addition, Ţurcan and Filik (2016) examined sarcastic expressions (sarcasm is a common form of irony) and found that unfamiliar sarcastic remarks engendered both early and late processing costs, but familiar sarcastic remarks only showed a late cost in eye-tracking. While it is sometimes difficult to distinguish between sarcastic and non-sarcastic irony (sarcastic comments necessarily involve comments in relation to another person, (Kreuz & Glucksberg, 1989), the majority of the items we used in the present study involved sarcasm (see Appendix C).

4.1.2. Relationship Between Irony Processing and Mentalizing Skills

A few recent neuroimaging studies (Spotorno et al., 2012; 2013) have highlighted a close relationship between ToM activations and irony processing in the brain. These studies, using neuro-typical participants, claim that the under-determination of a speaker's meaning is often to be resolved by the interlocutor when ToM network activations are recruited, especially in the right and left temporal parietal junction (rTPJ, lTPJ), in the medial prefrontal cortex (MPFC) and the precuneus (PC). These studies also report that ToM network activations happen at an early stage of irony processing, which suggests that the integration of linguistic code and contextual information takes place at an early stage. Other studies (e.g. Spotorno & Noveck, 2014) have emphasised the role of attitude ascription[11], a feature of ToM,

[11] In attitude ascriptions, people ascribe their opinion to a proposition (e.g. a fact, someone's belief or view, etc.). For example, 'Mary believes what Phil said' or 'Mary believes everything Phil believes' are both examples of propositional attitude ascriptions (see McKay & Nelson, 2014).

in irony processing, claiming that the mixed results in the psycholinguistic literature as to whether irony processing is more taxing than literal processing could be connected to the different ToM skills displayed by speakers. What these studies propose is that irony processing can become quicker and more straightforward if the individual more effectively recruits ToM networks.

In order to test whether ToM is implicated in the on-line processing of familiar ironies[12] in PwS and controls, we included two ToM measures, the Perspective-taking task and the Hinting Task in the Principal Component Analysis carried out in this research (see Chapter 2). In addition, other cognitive functions (working memory, cognitive control and flexibility and facial emotion recognition) besides ToM were also included in the correlational analyses below.

4.2. Hypotheses

We hypothesised that irony processing in the patient group would display processing discrepancies in relation to the control group and that participants in the patient group would more often interpret ironies in an incorrect way. We also hypothesised that ToM variables would be implicated in the irony effect size extracted from the eye-tracking experiment and that variables related to the manipulation of different sources of on-line information in working memory would be implicated in the irony effect size for the control group, but not the patient group (Ivanko and

[12] If patients had more difficulties in processing familiar ironies, not only unfamiliar ironies, which have been reported to be more tasking (see Filik et al., 2014), then they would have shown a more relevant discrepancy in relation to neurotypical controls.

Pexman, 2003). Finally, we hypothesized that effective irony processing involves the ability to juggle and use different sources of information input in working memory, and that this could be more challenging for PwS as they have shown a deficit in these cognitive functions.

4.3. Method

4.3.1. Participants

The same participants that took part in test battery 2 (see Chapter 2) were tested in the present experiment.

4.3.2. Stimuli and Procedure

We created 40 sentence fragments embedded in contexts that directed participants towards a literal, an ironic or a neutral interpretation of the irony and asked 66 participants to assess them in terms of ironicalness ("Is the sentence ironic?", with an explanation of what irony is), familiarity ("How familiar are you with the ironic expression?") and comprehensibility ("How easy is it to understand the ironic sentence?"). Items were divided over three separate lists, with a comparable number of ironic and non-ironic fragments. Participants who took part in the pre-testing were between 18 and 28 years of age, were all native English speakers and did not participate in the eye-tracking experiment.

Thirty-three items (see Table 17, and Appendix C) with the highest ratings for irony (*M* = 0.90/1, *SD* = 0.16) were selected for the study. These items were also considered familiar (*M* = 5.62/7, *SD* = 0.77) and comprehensible (*M* = 0.86/1, *SD* = 0.11). The neutral fragments were of the same length (*M* = 47.7 characters, *SD* = 7.50) as the ironic and literal fragments (*M* = 47.0, *SD* = 7.74). In the target region, neutral fragments had a different length (*M* = 5.8, *SD* = 2.04) from ironic and literal items (*M* = 4.9, *SD* =1.94). Ironic and literal target fragments were identical.

Table 17: Condition and stimuli examples

Condition	*Example*
Literal	The giant Rottweiler was barking menacingly at the visitors. One of them said, "I'm scared of that enormous beast" and then the owner decided to give it a treat.
Ironic	The little chiwawa was barking menacingly at the visitors. One of them said, "I'm scared of that enormous beast" and then the owner decided to give it a treat.
Neutral	The little chiwawa was barking menacingly at the visitors. One of them said, "I hope it will stop yapping soon" and then the owner decided to give it a treat.

4.4 Experiment 1: Eye-movements-while-reading task

We recorded eye movements using the Eyelink 1000 system operating at 1000 Hz (sampling every millisecond). Sentences were displayed on three to six equally spaced lines. The experimenter gave all participants a description of the experimental procedure and asked them to silently read short texts on a computer screen for comprehension. There were 14 occasional comprehension questions randomly spread across the 33 items. Participants answered them by pressing the “YES” or “NO” button on a button box. All participants had their head and chin stabilised by a head/chin rest. The study was granted the approval of the ethics committee of the University of Birmingham.

The items were divided over three lists, with an equal number of items per condition in each list so that each participant only read one version of each item. Each list was read by an equal number of participants in each group. The 33 items were intermixed by 114 filler items from different experiments.

4.4.1 Analysis

Less than 2% of the items with tracker loss[13] and items for which the preceding context was not processed attentively (i.e. evidence of skimming) were deleted from the analyses. No other cleaning operations were conducted. The two regions of interest were defined as follows: target (underlined) and spill-over (in italics): “The giant Rottweiler was barking menacingly at the visitors. One of them said, ‘<u>I’m scared of that enormous beast</u>’, *and then* the owner decided to give it a treat.” The spill-over region was defined as the first word following the target region if longer than three characters, otherwise the next two words. Because the target region for the neutral

[13] Tracker loss here refers to situations where the camera loses track of the pupil (e.g. due to excessive head movement, occlusion of the eyelid, mascara, etc)

condition contained different words and expressions from the ironic and literal target, comparisons with this condition must be treated cautiously. We chose a long target region because the focus of the analysis was more on the global ironic, higher-order interpretation, rather than the fine-grained time course of irony. Additionally, previous research using a moving window paradigm (Ivanko and Pexman, 2003) had indicated that longer reading times in irony processing were found either in the end of the target (final word) or in the spillover or after the last word of an ironic sentence (Pexman, Ferretti, and Katz, 2000). Using eye-tracking, Filik and Moxey (2010) also found longer fixation times in later reading measures, such as total time. When testing written irony, Kaakinen, Olkoniemi, Kinnari & Hyőna (2014) found that the irony effect related to an increased probability of rereading and duration of first-pass rereading and probability of regressing into the target sentence, and, for this reason, we measured regressions into target and spillover.

The eye movement results were analysed using a linear mixed effects model in R (R Core Team, 2016) and the package lme4, version 1.1-12 (Bates, Maechler, Bolker, & Walker, 2015), checking for effects of Group, Condition and the interaction between both variables. The following reading measures were analysed: First Pass (i.e. the time to read the region of interest before leaving the region left or right), Regression Path (i.e. the time from first entering the region of interest until leaving that region to continue on in the text), Regressions In (i.e. the likelihood of making a regression into a region of interest from a region further in the text), and Total Time (the sum of all fixations in a region of interest).

For the main analyses, we included random intercepts and random slopes (1 + condition/ppt) with both Condition and Group variables. Initially, we tried the maximally-appropriate random effects structure (Barr, Levy, Scheepers, & Tily, 2013), but due to non-convergence issues, we de-correlated the random effects structure for subjects and items. For the Regressions In measure, Condition was removed from the random effects structure due to non-convergence. The Regressions In data were analysed with generalized linear mixed effect models, using binomial regression (family=binomial, see details in Appendix C).[14]

Main effects of Condition and Group, as well as the interaction between Condition and Group, were tested with model comparisons using the anova function. Comparisons for a main effect of Condition were carried out using sum coding. As we are mainly interested in the effect irony has on reading, we compared the Irony condition to the Literal condition and to the Neutral condition. The comparison with the Neutral condition needs to be treated cautiously as it involves comparing slightly different regions of interest. Interactions were examined using comparisons between the conditions for each group separately.

4.4.2 Irony eye-movement experiment results & discussion

4.4.2.1 Reading Time Analysis

Average reading times for the different reading measures can be found in Table 18. An overview of the analyses can be found in Table 19.

[14] All the data were also analysed with ANOVAs, and the pattern of results was very similar to the LME results.

Table 18: Average reading times

Measure	*Target Region*			*Spill-over Region*		
	Irony	Literal	Neutral	Irony	Literal	Neutral
First-Pass						
Patients	902	894	879	331	315	338
Controls	891	834	876	332	297	292
All	*896*	*863*	*877*	*331*	*305*	*313*
Regression-Path						
Patients	1095	1091	1009	448	414	475
Controls	983	919	945	408	332	350
All	*1036*	*1002*	*976*	*427*	*371*	*407*
Regressions In						
Patients	30	27	21	23	20	22
Controls	19	14	15	22	17	20
All	*24*	*21*	*18*	*22*	*19*	*21*
Total Time						
Patients	1362	1188	1096	466	429	445
Controls	1102	989	1025	406	353	354
All	*1226*	*1084*	*1059*	*434*	*389*	*396*

Note: Reading times are in milliseconds; regressions data are in percentages

Table 19: Eye-movement analyses

Measure	*Target region*	*Spill-over region*
First Pass		
Condition	$\chi^2 = 3.89$, $p > .14$	$\chi^2 = 1.13$, $p > .56$
Group	$\chi^2 < 1$	$\chi^2 < 1$
Interaction	$\chi^2 < 1$	$\chi^2 < 1$
Regression Path		
Condition	$\chi^2 = 2.04$, $p > .36$	$\chi^2 = 1.48$, $p > .47$
Group	$\chi^2 < 1$	$\chi^2 = 1.17$, $p > .27$
Interaction	$\chi^2 = 3.30$, $p > .19$	$\chi^2 < 1$
Regressions In		
Condition	$\chi^2 = 6.74$, $p < .05$	$\chi^2 = 1.44$, $p > .39$
Irony vs. Literal	E = 0.032, SE = 0.013, $t = -2.34$, $p < .05$	
Irony vs. Neutral	E = 0.028, SE = 0.013, $t = -2.10$, $p < .05$	
Group	$\chi^2 = 8.90$, $p < .01$	$\chi^2 < 1$
Interaction	$\chi^2 = 1.91$, $p > .44$	$\chi^2 < 1$

Total Time		
Condition	$\chi^2 = 7.35$, $p < .05$	$\chi^2 = 2.60$, $p > .27$
Irony vs. Literal	E = 0.029, SE = 0.009, $t = -3.17$, $p < .01$	
Irony vs. Neutral	E = 0.010, SE = 0.009, $t = -1.13$, $p > .25$	
Group	$\chi^2 = 2.17$, $p > .14$	$\chi^2 = 1.45$, $p > .22$
Interaction	$\chi^2 = 8.98$, $p < .05$	$\chi^2 < 1$
Patients		
Irony vs. Literal	E = 0.041, SE = 0.014, $t = -3.01$, $p < .01$	
Irony vs. Neutral	E = 0.028, SE = 0.014, $t = -2.03$, $p < .05$	
Controls		
Irony vs. Literal	E = 0.017, SE = 0.012, $t = -1.46$, $p > .14$	
Irony vs. Neutral	E = 0.006, SE = 0.012, $t < 1$	

Notes. E stands for Estimate, SE for Standard Error.

We found a significant effect of condition in Regressions In and Total Time, with irony requiring significantly more regressions into the target region than literal constructions and neutrals and taking significantly longer to process than the other two conditions. A significant interaction was found for Total Time, with patients, but not controls, displaying significantly longer processing times when reading ironies in the target region when compared to literal constructions and neutrals. No effects were found for the spill-over region.

The reading time analyses indicated that both groups found ironies more taxing than literal processing, and that this effect was restricted to later processing measures and mainly in the target region, the region where the actual ironic expression is located. We also found that patients made significantly more regressions into the target region than controls did. The longer processing times for the irony condition might reflect the extra effort spent on interpreting the irony (Filik & Moxey, 2010) or difficulties in making sense of the passages, and it might even be that groups differ in this respect. Since it is not possible to extract from the eye-movement data exactly how a participant interpreted the text, we carried out an off-line sentence interpretation task (Experiment 2, see below).

Results are not completely in line with Filik et al. (2014), who found no difference in processing times between familiar ironies and non-ironic sentences. We did find an effect of condition in Regressions In and Total Time, with irony requiring significantly longer to process for both groups, neurotypical controls included. This result is in line, however, with Ţurcan & Filik's (2016) eye-tracking experiment of sarcastic utterances. It should be noted that in accordance with Filik et al's (2014) findings, we also found that the effect was restricted to the target region.

Our results are also in line with Au-Yeung, Kaakinen, Liversedge & Benson (2015) who found that irony processing was more taxing for both participants with ASD and neurotypical controls. They also found increased total reading times in various regions for participants with ASD compared with controls, even in non-ironic conditions.

4.4.2.2 Irony effect correlations

To estimate the additional effort that readers exhibited during irony interpretation, we subtracted the literal from the ironic processing time results for both groups in all eye-tracking measures. We labelled this processing difference as the "irony effect." The difference scores were then used in the correlations with the factors extracted from the first PCA (see Chapter 2). Since we are interested in discovering how patients diagnosed with schizophrenia and controls might differ in their reliance on certain cognitive operations, we analysed the two groups separately. For patients, four correlations came out as borderline (see Table 20), while controls showed significant correlations between the irony effect size and four components of the PCA (see Table 21).

Table 20: Irony effect correlations – Patients

Group	*Region*	*Measure*	*Component*	*Pearson score*
Patients	Spill-over	Regressions In	Difficulties in Cognitive Control	*r* = -.379 (*p* < .07)
		Regressions In	Hinting Comprehension	*r* = -.370 (*p* = .07)
		Regression Path	Perspective-taking	*r* = .359 (*p* < .08)
		Regression Path	Hinting Comprehension	*r* = -366 (*p* < .08)

Table 21: Irony effect correlations - Controls

Group	*Region*	*Measure*	*Component*	*Pearson score*
Controls	Target	Regressions In	Facial Emotion Recognition	*r* = .466*
	Spill-over	First Pass	Perspective-taking	*r* = .649**
		Regression Path	Facial Emotion Recognition	*r* = .444*
		Regressions In	Flexibility and Working Memory	*r* = -.476*

Note: * = *p* < .05; ** = *p* < .01.

Most correlations between the irony effect and the cognitive measures appeared in the spill-over region, and none were found for the early reading measures in the target region. This, together with a lack of early effects in the target region in the reading data, suggests that interpreting an expression as ironic might not be resolved immediately upon encountering the ironic remark (Ţurcan & Filik, 2016; see also Staub, Grant, Clifton & Rayner, 2009, for an overview of delayed higher-order interpretations).

The irony effect for the patient group displayed borderline correlations with Regressions In and Regression Path, both in the spill-over region. The borderline irony effect correlation for Regressions In and the Difficulties in Cognitive Control was negative, meaning that the more difficulties PwS reported in the Cognitive Control and in the Hinting Task (see Table 7), the fewer regressions they made into the spill-over. This might suggest that the patients who find tasks involving cognitive control and indirect language (specifically hints) more difficult, are less likely to notice possible ironic interpretations and spend less time appreciating it. The irony effect for Regression Path in the spill-over region displayed a borderline positive correlation with the Perspective-taking Error component, meaning that patients who made more errors in the on-line perspective-taking task also showed a larger irony effect. In this case, failures to appreciate Self and Other perspectives can lead to longer irony processing times, maybe not due to actual appreciation of irony, but to difficulties in irony processing.

Irony processing in controls was not linked with the Difficulties in Cognitive Control component, which was true at a borderline level in the patients' data. Already for one of the earliest measures immediately following the ironic expression (First Pass in the spill-over region, see Table 8) do we see the Hinting Comprehension component correlating with the size of the irony effect such that people who are better at understanding hints also display a larger irony effect. In addition, regressions into the target region, as well as the Regression Path measure for the spill-over region, were positively correlated with the Facial Emotion Recognition component, indicating that people who are better at recognizing other people's facial emotions are more likely to make additional effort to process the ironic meaning. The fact that the Facial Emotion Recognition component appears correlated with the irony effect in the control group is in line with Spotorno et al.'s (2013) finding that attitude ascription and social skills can have a fine-tuning role in irony processing. Finally, correlations were also observed between the irony effect in the Total Time and Regressions In measures and the flexibility and working memory component, suggesting that controls who scored higher on this component also exhibited a larger irony effect.

If we consider the control group, we see that the components related to perspective-taking and facial emotion recognition, as well as Flexibility and Working Memory are the most important processes related to irony processing. It should be noted that facial emotion recognition has previously been linked to ToM processing. For example, Sucksmith, Allison, Baron-Cohen, Chakrabarti, and Hoekstra (2013) found that adults with autism spectrum conditions (ASC) scored lower on a measure of empathy as well as on the KDEF measure. More specifically, the ASC group was worse at recognizing five out of six emotions expressed in the pictures used in this test, indicating that they struggled with understanding what other people might be feeling as conveyed in their facial expressions.

4.5. Experiment 2: Sentence Interpretation Task

4.5.1. Participants

The same participants who took part in the eye-tracking experiment participated in the Sentence Interpretation task. There was an average time gap of at least seven months between the eye-tracking and the Sentence Interpretation task. However, for this task, we had fewer participants (PwS 25, controls, 21), as some of the participants who took part in eye-movement experiment had moved outside England.

4.5.2. Stimuli

We used the same fragments as in the eye-tracking experiment, except that, in the sentence interpretation task, participants received a different list from the one they had received before. We did not include the neutral condition in this test due to time constraints. Participants who had seen an item in the ironic version would be presented with its literal version; participants who had seen either literal or neutral would now be presented with their ironic version.

4.5.3 Procedure

The experimenter read aloud all the fragments in the Sentence Interpretation task, one at a time. Participants expressed their individual interpretation of each fragment and communicated whether they made sense of them or not. Fragments were also mixed in their two conditions, so that there would not be an expectation in regard to the fragments being ironic. The fragments were read to participants up to and including the target region, without the spill-over and the following context. One hundred and forty-four items from other experiments were included as fillers.

4.5.4. Hypothesis

We hypothesised that patients would make more literality mistakes than controls when giving their interpretation of the ironic fragments. Literality mistakes comprise of answers indicating that the ironic fragment didn't make any sense or that it was contradictory.

4.5.5 Sentence Interpretation task results

There were significant differences between patients and controls in irony processing: the patient group (M = 41.7% literality errors, SD = 31) made significantly more mistakes when processing ironic fragments compared to the control group (M =

12.7% literality errors, *SD* = 14; $t(44) = 3.95$, $p < .001$). This supports Langdon et al. (2002), as they found poorer irony comprehension among patients. Indeed, given that almost 42% of the ironic fragments, which nevertheless received high ironicalness ratings (*M* = 0.93/1.0) in the pre-testing, were incorrectly understood by patients, is quite remarkable (details in relation to participants' percentage of mistakes in irony interpretation can be found in Appendix C).

Results for the literal interpretations revealed that patients made significantly fewer mistakes when processing literal fragments when compared to ironic fragments (*M* = 4.4% errors in literal processing, *SD* = 7.64), $t(24) = 5.773$, $p < .001$. Controls displayed similar results in literal processing errors (*M* = 3.0% errors, *SD* = 6.25) when compared to patients. An independent samples *t*-test revealed no significant differences between the two groups in literal processing, (*M* = 3.53, *SD* = 13.44, $t(44) = .772$, $p = .444$).

4.6 General Discussion

The first finding to note is that processing of familiar ironic expressions did not lead to early processing differences compared to interpreting the same expressions literally. We did observe that processing ironies engendered extra effort in later reading measures. This finding is in line with evidence from eye movement experiments testing familiar sarcasm (Ţurcan & Filik, 2016) but not with the lack of an effect for familiar non-sarcastic ironies (Filik et al., 2014). One possible explanation for this delayed effect is that both the literal and ironic interpretations are retained (e.g. Giora, 1995; 1997) and the resulting conflict is resolved by contextual integration, which is supposed to be more difficult for figurative expressions (Tartter et al., 2002; Turner & Katz, 1997).

More pertinent for the present research is the finding that the irony effect extracted from the eye movement experiment pointed to facial emotion recognition, flexibility, working memory and ToM as the more relevant cognitive functions associated with irony processing. This result indicates a close relationship between mentalizing activations and irony processing (Spotorno et al., 2012; 2013). The observation that this already happened in a relatively early measure in the control group, such as First Pass, corroborates the idea that ToM network activations happen at an early stage of the irony reading (Spotorno et al., 2013).

When considering the results obtained in the correlations between the irony effect and the principal components, we found that overall, considering both groups, a link between the on-line manipulation of complex and different information in working memory, cognitive control, flexibility and ToM skills appeared to be relevant in irony processing.

It is remarkable that difficulties in perspective-taking and in cognitive control among PwS correlated with increased processing effort for ironic expressions, which suggests that these functions are relevant for successful irony processing. In essence, we found larger irony effects for patients that were better on these cognitive measures. This is in line with controls, who showed increased processing for ironies compared to literal expressions. Hence, we can speculate that better performance on these measures might lead to more effective, and more standard, irony processing.

It is equally noteworthy that flexibility and working memory and ToM skills (Hinting Comprehension component) emerged as relevant functions for successful irony processing in controls, and that these components did not emerge as influential for patients. This suggests a qualitative difference in irony processing between both groups, which means that patients might have interpreted ironies differently from controls, or maybe failed to interpret them at all. Indeed, results from the Sentence Interpretation Task confirm that even with unrestricted time to process the expressions, patients often did not arrive at the appropriate ironic interpretation. While patients did not differ from controls in understanding literal fragments, they perceived ironic fragments as non-sensical in almost 42% of the cases. Hence, it is quite clear that patients don't seem to appreciate irony with a comparable level of accuracy as controls.

It is important to keep in mind that the results of the on-line (eye-tracking) and off-line (sentence interpretation task) measures do not necessarily tap into the same processes and interpretations. For example, patients, when given ample time to interpret an expression, might start making a multitude of idiosyncratic associations, such that their final interpretation might be quite far removed from the actual information provided in the text. This process might take time, and might not be captured in the eye movement measures. One hypothesis following from this view is that patients and controls might start off similarly during initial processing, but that patients then go off on different tangents, which controls might be less likely to do. However, as patients do not seem to use the same cognitive functions during on-line processing as controls (see correlations with PCA), it might be that even at an early stage there are already important differences on how they approach information. In any case, what our research makes clear is that when testing on-line processing in PwS, one needs to include an off-line assessment as well in order to arrive at a clearer understanding of patients' interpretations of text.

In conclusion, while the main eye movement analyses only indicated small differences in irony processing between controls and schizophrenic patients, analyses including relevant cognitive measures show that there were substantial discrepancies between the two groups. The results suggest that patients might often fail to recruit crucial cognitive functions such as working memory, flexibility of thought and ToM, making non-literal, ironic interpretation extremely challenging. However, there is some evidence that indicates that patients who are better at perspective-taking and cognitive control are more similar to controls, suggesting more successful irony processing. Nevertheless, it is clear that, as a group, patients find ironies quite puzzling.

Chapter 5

METAPHOR PROCESSING STUDY

5.1 Introduction

It has been reported that patients diagnosed with schizophrenia display deficits both in language processing (Kiang et al. 2008; Kuperberg, 2010a, 2010b; Langdom et al., 2002; Sela, Lavidor & Mitchell, 2015; Tavano et al., 2008) and language production (Kuperberg, 2010a, 2010b). Some of these deficits also involve figurative language processing, especially metaphor comprehension as measured by proverb interpretations (e.g. *Don't judge a book by its cover*) in psychiatric scales, such as the the Positive and Negative Syndrome Scale (PANSS), a scale designed to assess the severity of symptoms related to schizophrenia, including difficulty in abstract thinking, a symptom related to poor metaphor comprehension.

Impairments in figurative language processing in schizophrenia have often been related to either deficits in executive functions (Hoff et al., 1999; Kuperberg, 2010a, 2010b, Lee & Park, 2005) or in semantic and contextual integration (e.g. David, Kuperberg & McGuire, 1998; Kircher et al., 2007; Kuperberg, 2000; Langdon et al., 2002; Sitnikova, Salisbury, Kuperberg & Holcomb, 2002; Titone, Levy, & Holzman, 2000). In addition, poor social language skills (Tavano et al, 2008) and poor Theory of Mind (ToM) skills (Brűne & Bodenstein, 2005, Brűne, 2005) have also been related to poor figurative language interpretation in schizophrenia.

However, there are different kinds of figurative and different kinds of non-literal expressions. For example, idioms such as *kick the bucket* share some similarities with proverbs but don't incorporate advice or a truism and their meaning is unrelated to the meanings of their individual words. Research in idiom processing in schizophrenia has reported mixed results, and it's unclear whether patients diagnosed with schizophrenia have an actual deficit in idiom processing. Some findings report that PwS only have difficulties in supressing the competing literal meanings, but not in understanding the non-literal meanings (Titone et al., 2002) while other findings report no differences in comprehension of idiomatic sentences between PwS and controls (Pesciarelli et al., 2014). Pesciarelli et al. (2014) and Schettino et al. (2010) related the inability to interpret idioms with poor verbal working memory and poor executive functions.

As for metaphor processing in schizophrenia, Mitchell and Crow (2005) and Elvevag et al. (2011) demonstrated that PwS tend to interpret metaphors literally, although familiarity in some studies appeared to play a role, with conventionalized metaphors being reported as easier to be processed by PwS in comparison to novel metaphors (De Grauve et al., 2010). However, in a study using fMRI, Mashal, Vishne, Laor and Titone (2013) reported contradictory findings, with a poorer comprehension of both novel and conventional metaphors found in patients with schizophrenia when compared to neurotypical controls. This study also highlighted that poorer abstract thinking as measured in the PANSS was correlated with diminished conventional metaphor understanding and the authors speculated that an increased BOLD response in the left medial frontal gyrus indicated an additional recruitment of cognitive resources, such as working memory. Results of impaired conventional and novel metaphor processing in PwS were replicated by Mossaheb et al. (2014), who also reported that performance in a conventional metaphor paraphrasing and novel metaphor generation task was predicted by the severity of negative symptoms, with patients exhibiting more negative symptoms scoring more poorly on these tasks.

Mo, Su, Chan and Liu (2008) found impaired metaphor comprehension in patients diagnosed with schizophrenia which IQ (the WAIS-R was used to compare control and patient group) did not explain. This study also reported a correlation between metaphor comprehension and second-order false belief understanding, which had been previously connected in literature with irony processing (Happé, 1993,1995; Langdon, Coultheart & Ward., 2002b; Langdon, Davies & Coultheart, 2002a). As for executive function impairments in schizophrenia, studies by Hoff et al. (1999), Kuperberg (2010a; 2010b) and Lee and Park (2005) corroborated the hypothesis that not only Theory of Mind, but also executive function deficits are present in the disorder, with Kuperberg (2010a; 2010b) arguing that poor working memory skills could diminish contextual construction and contextual information use.

David, Kuperberg and McGuire (2000) and Kuperberg (2000) reported that violations of the semantic context were not spotted by PwS who presented thought disorder. In general, severity of thought disorder has been linked to poor cognitive performance in tasks involving executive functioning (Kerns & Berenbaum, 2002; Kuperberg, 2010a; 2010b), although thought disorder is not a requirement for deficits in online contextual language processing and use (Kuperberg, McGuire, & David, 2000). Despite the fact that the ability to use contextual information has been reported as impaired in schizophrenia (Kuperberg, 2010a, 2010b), a few studies highlighted the positive impact of context familiarity (Ditman & Kuperberg, 2010; Sitnikova, Perrone, Goff & Kuperberg, 2010), suggesting that more familiar contexts were easier to be processed by patients when compared to unfamiliar contexts.

5.1.1 Theories of Metaphor Comprehension

Quite a few models of metaphor comprehension have been proposed over the past decades. One of the first models claimed that metaphor interpretation included steps (Grice, 1975; Searle, 1979), with listeners/readers rejecting the literal meaning and finding a figurative interpretation that is context-appropriate. In this view, literal interpretations would take precedence over the metaphoric ones and metaphors should always take longer to process than literal statements. A second model claimed that metaphor perception was optional when the literal meaning made sense (Glucksberg, Gildea, & Bookin, 1982; Keysar, 1989). This means that in the absence of a triggering inappropriate literal interpretation, metaphoric interpretation would be a matter of choice to the listener/reader. A third model proposed that when the unfitness to the context presented by the metaphor is recognised, the expression will be transformed into an implicit simile, i.e. an indirect comparison (Ortony, 1979b). Hence, metaphors such as “My job is a jail” would be interpreted as “My job is like a jail.”

Glucksberg and Keysar (1990) criticised these previous metaphor comprehension theories by pointing out that if metaphors were simply indirect comparisons, reversing the metaphoric comparison would not make it hard to understand or change its meaning completely. However, that was not the case when metaphors such as “The surgeon is a butcher” (the surgeon is unskilled) were inverted to “The butcher is a surgeon” (the butcher is very skilled and precise), where meanings are completely different. They propose that metaphors such as “My job is a jail” or “The surgeon is a butcher” are class inclusion assertions, where features of “job” or “surgeon” are compared with features of “jail” or “butcher”, not actual implicit comparisons. Hence, metaphors are processed in similar ways to literal class inclusion statements (such as "The jail is a building"). A word such as "jail" can refer to different superordinate categories (e.g. a building, types of punishment, but also situations that might be unpleasant). During metaphor comprehension, the topic (job) will select the relevant features from the vehicle (jail), in this case the unnamed category of unpleasant situations, and interpretation then becomes straightforward.

Later on, Gibbs (1994) proposed a "direct access" view to metaphor comprehension, which claims that metaphors are processed as straightforwardly as literals. In this view, contextual processes would come into play immediately, so that one can access or construct the metaphoric interpretation without additional cost. Another version of the direct access view is the "constraint-based satisfaction model," which argues that metaphoric comprehension is achieved if contextual constraints are more compelling than lexical ones (Katz & Ferretti, 2001; Pexman, Ferretti, & Katz, 2000). In this view, just like in the direct access view, metaphors would be processed straightforwardly because contextual and lexical meanings would be equally available to listeners, with one winning over the other according to how compelling or constraining contextual clues are made available to the listener/reader.

The graded salience hypothesis (Giora, 1997, 1999, 2003; Peleg, Giora & Fein, 2001, see Chapter 4) also applies to metaphor processing, assuming that there are two separate mechanisms of metaphor processing, one responsible for lexical processing and the other responsible for linguistic and extra-linguistic processing, both running in parallel. The mechanism responsible for contextual integration is thought to be sensitive to salience (e.g. frequency, conventionality, prototypicality). Salient meanings are encoded in one's mental lexicon, but the degree of saliency can vary over time and situation. It is thought that when an interpretation is very salient, whether it is literal or figurative, no processing cost will ensue. There are several instances where figurative language, metaphors included, can be understood as quickly as literal speech, especially when these expressions are encountered in rich linguistic contexts (Gibbs, 1994; 2002), where enough contextual information for the listener or reader is provided.

One common ground shared by all theories is that metaphoric comprehension requires both linguistic and non-linguistic inference. In addition, the literature has highlighted that mentalising skills may be required when processing some forms of figurative language, especially irony (Happé, 1993). It has also been observed that metaphor comprehension, unlike irony comprehension, would not require a listener's understanding of a speaker's judgment of a specific situation, but only the meaning conveyed in the figurative expression, consequently, irony comprehension would require a step further in mentalising skills when compared to metaphor comprehension (Happé, 1993, 1995; Langdon et al., 2002a, b). One aim of the present study is to examine how Theory of Mind and mentalising skills intermingle with metaphor comprehension, if at all. The role of other cognitive skills involved in metaphor comprehension will also be explored.

For the metaphor study in this thesis, following the same procedure adopted in the irony study, we will present an eye-movement experiment, as well as an off-line sentence interpretation task, where participants are required to verbally communicate their interpretation of metaphoric sentences. In the eye-movement experiment, we expect PwS, not controls, to display more difficulty in metaphor interpretation compared with literal items. This could be translated by more regressions into the target region. We also expect all participants, not only controls, to be able to display a nonsensicality effect, which would be translated by significantly longer processing times in the nonsensical condition. In the off-line experiment, we expect PwS to make significantly more mistakes in metaphor comprehension when compared to controls.

5.2 Method

5.2.1. Stimuli Pre-Testing

We created 48 items (see Table 19 for an example and Appendix D for the full list of items) with lexicalised and novel metaphors and had 66 native English speakers assess them, together with 11 non-sensical distractors. Items were divided in three separate lists, with an equal number of conventional and novel metaphors.

Participants who took part in the pre-testing were between 18 and 28 years of age and they came from the University of Birmingham undergraduate population and from an international school in London (Southbank International School) where only native speakers of English were selected. Every participant had to assess whether the sentences made sense or not (binary choice), whether they were easy to understand or not (scale from 1 to 7), whether they were literal[15] or not, and whether they sounded familiar to them or not (scale from 1 to 7). The sentences differed in relation to three conditions: metaphorical, literal and nonsensical (see a detailed explanation for this condition below).

In addition, to control for predictability in the sentences, we administered a

[15] The definition of "literal" was appropriately provided on the instructions sheet with clear examples. A copy of the task is included in the Appendix.

sentence completion task to the same 66 participants. The predictability completion pre-test was given to participants prior to the sensicality, ease of understanding, figurativeness and familiarity tests. Participants had to complete the sentence fragments with the first word or words that came to their minds. By administering this task, we could assess whether participants would use the same word(s) or similar ones used in the metaphorical, literal and non-sensical sentences. We avoided as much as possible target words in our stimuli that had been used by the participants in this pre-test. The predictability of the target words selected was therefore very low (metaphors: < 1%, literal and nonsensical: 0%). The target words were identical in the three conditions. The words used in topic position were controlled for log-frequency (using N-Watch; Davis, 2005: metaphor: 1.63, literal: 1.41, nonsensical: 1.46: $p > .25$), and length in number of characters (metaphor: 6.9, literal: 6.8, nonsensical: 6.7: $F < 1$).

For the 33 selected stimuli, a paired-samples t-test revealed that the sensicality ratings did not differ between metaphoric ($M = .90$, $SD = .17$) and literal expressions ($M =.96$, $SD = .06$); $t(32) = 1.66$, $p > .10$. The nonsensical expressions were indeed rated as significantly less sensical ($M = .34$, $SD = .26$; ps $< .001$). Hence, the metaphors and literal expressions made equal sense to participants. However, as for ease of understanding, there was a significant difference in the scores between metaphors ($M = 5.55$, $SD = .98$) and literals ($M = 6.21$, $SD = .62$); $t(32) = 3.07$, $p < .01$, meaning that metaphors were judged to be more difficult to understand than literal expressions. Nevertheless, the average suggests that, overall, the metaphors' ease of understanding was still quite high. In contrast, nonsensical expressions were judged to be significantly more difficult to understand ($M = 2.88$, $SD = 1.03$).

We also checked the familiarity of the expressions. The metaphors were considered as familiar as their literal counterparts (metaphor: $M = 5.14$, $SD = 1.14$, literal: $M = 5.24$, $SD = .92$), $t < 1$. The nonsensical expressions were judged to be rather unfamiliar, as expected ($M = 2.16$, $SD = .91$).

Hence, the nonsensical items we created were really considered nonsensical in the pre-testing. Non-sensical items were included in the pre-testing and in the actual testing because we wanted to check whether PwS would be able to recognise semantic violations in the sentences, which was reported to be deficient by Kuperberg (2000) in patients displaying thought disturbance. The tables with the results from all three conditions (metaphorical, literal and nonsensical) are included in Appendix D.

Table 22 – Metaphor experiment examples

Condition	*Example*
Metaphor	Jacqueline claims that her life is a fashion show and that she will enjoy it.
Literal	Jacqueline claims that her event is a fashion show and that she will enjoy it.
Nonsensical	Laura affirmed that her train is a fashion show and that she will enjoy it.

5.2.2. Participants

The same participants that took part in test batteries 1 and 2 described in Chapter 4 participated in this experiment.

5.2.3. Procedure

The experimenter gave all participants a description of the experimental procedure and informed them that they would be reading short texts on a computer screen. The experimenter made it clear to participants that they were not supposed to read the fragments aloud and that they had to answer occasional comprehension questions using the joystick and pressing the "YES" or "NO" button. All participants had their head and chin stabilised by a head/chin rest. The study was approved by the ethics committee of the University of Birmingham.

5.3 Experiment 1: Eye-movements while reading task

We recorded eye movements with the Eyelink 1000 system operating at 1000 Hz (sampling every millisecond). Sentences were displayed between two and four equally spaced lines. We analysed the same reading measures as in the irony experiment (Chapter 4).

5.3.1. Analysis

Less than 2% of the items with tracker loss[16] and items for which the preceding

[16] Tracker loss here, like for the Irony Experiment, refers to camera losing track of the pupil (e.g. due to excessive head movement, occlusion of the eyelid, participant wearing mascara, etc)

context was not processed attentively (i.e. evidence of skimming) were deleted from the analyses. The two regions of interest are exemplified as follows: target (underlined) and spill-over (in italics): "Jacqueline claims that her life is <u>a fashion show</u> *and that*…" The spill-over region was defined as the first word following the target region if longer than three characters, otherwise the next two words.

Similarly to the irony eye-tracking experiment (see Chapter 4), we analysed the results using a linear mixed effects model in R (R Core Team, 2016) and the package lme4, version 1.1-12 (Bates et al., 2015). Like in the irony analysis, effects of Group, Condition and interaction were observed. The same reading fixation measures observed for the irony experiment analysis (see Chapter 4) were observed for the metaphor experiment analysis.

Following the same procedure used for the irony eye-tracking experiment data analysis, we included random intercepts and random slopes with the Condition variable. Like what happened in the irony experiment, we had non-convergence issues and we had to de-correlate the random effects structure for subjects. The random effects structure did not include Condition for the Regressions Into the regions of interest because it caused non-convergence. Like in the irony experiment analysis, we used a generalized linear mixed effect models, using binomial regression (family=binomial, see Appendix D) to analyse the Regressions In data.

We used the Anova function to test for effects of Condition and Group, as well as the interaction between Condition and Group. We also used sum coding for comparisons related to the effect of Condition. Since we were interested in investigating the effect metaphor has on reading, we compared the Metaphor condition to the Literal condition and to the Nonsensical condition. Interactions and Condition effects were examined further using comparisons between the conditions for each group separately. However, to find out exactly how each group processed the conditions, we ran mean comparisons between literal and metaphors, literal and nonsensical items for each group separately, even when the interaction was not significant.

5.3.2. Metaphor eye-movement experiment results

Average reading times for the different reading measures can be found in Table 23. An overview of the analyses can be found in Table 24.

Table 23 – Reading Times – Target and spill-over regions

	Target region			Spill-over region		
	All	Patients	Controls	*All*	Patients	Controls
First Pass						
Metaphor	*443 (223)*	425 (190)	464 (260)	*343 (128)*	356 (149)	327 (100)
Literal	*416 (162)*	420 (169)	412 (158)	*354 (127)*	374 (139)	331 (112)
Nonsense	*452 (162)*	458 (166)	445 (161)	*360 (134)*	380 (165)	338 (83)
Regression Path						
Metaphor	*678 (400)*	760 (440)	582 (329)	*486 (254)*	501 (323)	469 (141)
Literal	*645 (263)*	711 (303)	570 (189)	*449 (223)*	507 (261)	382 (150)

Nonsense	*758 (370)*	853 (445)	646 (220)	*589 (232)*	604 (237)	572 (228)
Regressions In						
Metaphor	*.20 (.16)*	.19 (.17)	.21 (.16)	*.26 (.17)*	.27 (.18)	.24 (.16)
Literal	*.20 (.18)*	.27 (.20)	.13 (.13)	*.26 (.18)*	.30 (.20)	.21 (.14)
Nonsense	*.22 (.16)*	.25 (.16)	.20 (.16)	*.29 (.19)*	.30 (.20)	.28 (.17)
Total Time						
Metaphor	*734 (446)*	790 (501)	669 (370)	*519 (220)*	551 (265)	480 (146)
Literal	*674 (334)*	730 (397)	609 (230)	*505 (225)*	552 (268)	449 (148)
Nonsense	*825 (333)*	865 (362)	777 (295)	*594 (261)*	613 (301)	571 (209)

Note: Reading times are in milliseconds; regressions data are in percentages, standard deviations are between brackets.

Table 24: Eye-movement analyses - Metaphor

	Target		Spillover	
	χ^2	α	χ^2	α
First Pass				
Condition	3.93	> .14	2.83	> .24
Group	2.54	> .11	6.96	< .01
Interaction	< 1		< 1	

Literal vs. Metaphor				
Patients	*t* < 1		*t* = 1.07	*p* > .28
Controls	*t* < 1		*t* < 1	
Regression Path				
Condition	13.10	< .01	11.43	<.01
Literal vs. Metaphor	*t* < 1		*t* = 1.15	*p* > .25
Literal vs. Nonsense	*t* = 3.04	*p* < .01	*t* = 4.29	*p* < .001
Group	4.02	< .05	1.41	> .23
Interaction	1.44	> .48	2.82	> .24
Literal vs. Metaphor				
Patients	*t* < 1		*t* = 1.28	*p* = .20
Controls	*t* < 1		*t* < 1	
Literal vs. Nonsense				
Patients	*t* = 2.40	< .05	*t* = 2.35	*p* < .05
Controls	*t* = 1.90	*p* < .06	*t* = 4.05	*p* < .001
Regressions In				
Condition	1.13	> .56	1.77	> .41
Group	1.46	> .22	< 1	
Interaction	10.05	< .01	2.25	> .32

Literal vs. Metaphor Patients	$t = 2.01$	$p < .05$	$t < 1$	
Literal vs. Metaphor - Controls	$t = 1.55$	$p > .12$	$t < 1$	
Literal vs. Nonsense - Patients	$t < 1$		$t < 1$	
Literal vs. Nonsense - Controls	$t < 1$		$t = 1.48$	$p > .14$
Total Time				
Condition	14.98	< .001	24.59	< .001
Group	< 1		<2.47	<1
Interaction	< 1		2.22	> .32
Literal vs. Metaphor				
Patients	$t < 1$		$t < 1$	
Controls	$t < 1$		$t = 1.08$	$p > .27$
Literal vs. Nonsense				
Patients	$t = 2.31$	$p < .05$	$t = 1.89$	$p < .06$
Controls	$t = 3.48$	$p < .001$	$t = 3.89$	$p < .001$

5.3.2.1. Target Region

We did not find a significant effect of Condition, Group or an interaction in First Pass. For the Regression Path measure, there was an effect of Condition with nonsensical items taking significantly longer and being more taxing to be processed than literal sentences. The planned comparisons for each group separately indicated that the same pattern was found for both PwS and controls. There was also a main effect of Group, with PwS taking longer to read than controls.

For the Regressions In measure, we found a significant interaction, with PwS making significantly more regressions into the target when processing metaphors compared to literal items, which was not found for the control group. In Total Time, we found a significant effect of Condition, with nonsensical items taking significantly longer to be processed compared to literals. This effect was true for both groups, patients and controls, although controls showed a much more robust effect than patients in this measure. In conclusion, we can say that, in general, nonsensical items required significantly longer processing times in the target region when compared to literals. This means that for both groups a nonsensicality effect was present. For patients, we also found a higher number of regressions for the metaphor condition when compared to the literal condition. The fact that the nonsensicality effect was present not only for controls, but also for patients might be an indication that thought disturbance was not perhaps a major symptom present in the patient group as otherwise we would not have expected a difference between the literal or metaphor and nonsensical conditions (see David, Kuperberg & McGuire, 1998; Kuperberg, 2000). In addition, the fact that PwS made significantly more regressions into the target when processing metaphors when compared to literal items might suggest that they were trying to make sense of the figurativeness expressed by the metaphor in the target region.

Summarising, the results displayed in Table 22 confirm the hypothesis that PwS make significantly more regressions into the target region when compared to controls, they also hightlight that nonsensicality required longer processing times from all participants, as we expected, considering that the patients who took part in this study had been on second-generation anti-psychotic medication for more than ten years and were stabilised.

5.3.2.2 Spill-over Region

We found a significant effect of Group in First Pass, with PwS taking longer to read than controls. We found a significant effect of Condition for the Regression Path measure, due to nonsensical items engendering longer fixation times. The same pattern was found for Total Time. The planned comparisons for both measures indicated that the nonsense effect was more robust for controls than for PwS, with only a borderline significant effect for PwS in Total Time. This might suggest that patients had difficulties processing not only nonsensical items, but literal items as well, which was not true for the control group.

In general, results did not indicate a significant difference for metaphor processing in relation to literal processing, though it is important to point out that the metaphoric expressions were rated as quite well established (5.1/7). Patients displayed a tendency to be slower than controls in all conditions, metaphors, literals and nonsense. By and large, the pattern was comparable for both groups except that PwS showed in their regression data that the metaphors were less easily processed than the literal expressions, and that the difference in fixation durations (Regression Path and Total Time) between literal and nonsensical items was somewhat less than one would expect based on the control data.

5.3.3. Metaphor Effect Correlations

The "metaphor effect" is calculated by subtracting the literal processing times from the metaphor processing times. It is in fact a numerical expression of the effort participants made while reading the metaphors used in the study in comparison to literals. We processed these values in a correlation with the components extracted from the PCA analysis (see Chapter 2). Judging from the eye-movement while reading results, we suspected that the cognitive skills employed by PwS and controls might differ. For this reason, we decided to analyse each group separately. Results of the metaphor effect correlations can be found in Table 25.

Table 25: Metaphor effect correlations with components extracted from PCA

	Region	*Measure*	*Component*	*Pearson score*
Controls	Spill-over	Regression Path	Flexibility and Working Memory	$r = -.572^{**}$

Note: Significance level is indicated by stars: *p <.05; **p < .01; ***p < .001.

The metaphor effect for the patient group did not correlate with any component extracted from the PCA analysis. For controls, we found a negative correlation between C1 (Flexibility and Working Memory) and the metaphor effect for Regression Path in the spill-over region. This suggests that controls who showed greater flexibility and a more effective working memory displayed a smaller metaphor effect. This result makes sense, as participants with better flexibility and working memory would process metaphors more straightforwardly. The result also suggests that metaphor interpretation might not happen during the early reading stages and might not be resolved immediately upon encountering the target, spilling over to subsequent material, especially when cognitive flexibility and working memory functions are less efficient.

The metaphor effect correlation results do not support the view that PwS process metaphors in the same way as neurotypical controls (Bonis, Epelbaum, Deffez & Feline, 1997; Iakimova, Passerieux, Laurent and Hardy-Bayle, 2005). Rather, patients do not seem to use flexibility and working memory in the same way as controls, which we believe to be a novel finding.

5.3.4. Metaphor Eye-movement Results Discussion

The eye-tracking results suggested that the processing of the metaphors, compared to literal expressions, did not result in substantial processing costs, though the Regressions In results for the PwS did indicate some extra effort was needed to interpret metaphors. Both groups presented a significant nonsense effect, with controls displaying a much more robust effect than patients in the later eye movement measures. Further examination using PCA component values indicated a qualitative difference between groups, with patients not using certain cognitive functions such as flexibility and working memory in the same way as controls when resolving metaphoric expressions. Since controls showed a significant correlation with the Flexibility and Working Memory component, we can speculate that cognitive flexibility and working memory are relevant cognitive functions for metaphor processing.

The fact that cognitive functions such as cognitive flexibility and working memory are recruited during later stages of reading and not in the target region, might be an indication that metaphors may not always be processed immediately and/or straightforwardly. When looking at the results of the control group, we did not find any statistically significant differences between literal and metaphoric expressions. This runs counter the predictions from the standard pragmatic view, which predicts that metaphors should always take longer than literal expressions. These results could be reconciled with the direct access view, though the correlational data might help refine this view as they suggest that individual differences with respect to flexibility and working memory can impact how difficult it is to attain a metaphoric interpretation. The results could also be explained according to the graded salience view, though only when assuming that the items used were indeed quite familiar to the readers.

Finally, we can say that the eye-tracking results revealed that overall, patients displayed increased processing times for all conditions when compared to controls. However, as far as eye movement results are concerned, we cannot say that the patterns presented by both groups were vastly dissimilar. Both patients and controls displayed a clear nonsense effect, though literal processing was not quite the same in the patient group, as the discrepancy in processing times between literal and nonsensical items was much larger among neurotypical controls. Taken together, the eye-tracking results and the correlational analyses revealed small, but relevant differences in how patients and controls processed the different expressions on-line. However, on-line results do not allow us to infer whether patients and controls ultimately arrived at the same interpretation or not, which we investigated in a second experiment using a sentence interpretation task.

5.4 Experiment 2: Sentence Interpretation Task

We decided to run a second behavioural experiment because, although the eye-tracking was very useful at pointing out differences in reading patterns across conditions, it could not really tell us how patients were interpreting the sentences they read and whether the sentences in the different conditions (literal, metaphorical, or nonsensical form) made sense to them or not. The behavioural task we designed aimed at clarifying patients' ultimate interpretation of the sentences. It is possible that a difference between on-line and off-line interpretations may appear, as, in an off-line task, participants have more time to reflect and come up with different meaning possibilities, which in the case of the PwS, might include lots of extraneous interpretations and meaning connections.

5.4.1 Participants

The same participants who took part in the eye-tracking experiment participated in the Sentence Interpretation task. A time gap of at least seven months between experiments was imposed. However, for the Sentence Interpretation task, we had fewer participants (PwS 25, controls, 21), as some of the participants who took part in eye-movement experiment had moved outside England.

5.4.2 Stimuli

We used the same stimuli as in the eye-tracking experiment, but this time participants were given a different list from the one they had received in the first experiment, which means that they did not have to interpret the sentence in the same condition from the first experiment. For example, if they had read a specific sentence containing a metaphor in the eye-tracking experiment, then they would have to interpret this sentence in its literal or nonsensical form in the Sentence Interpretation task.

5.4.3 Procedure

Sentences were read aloud, one at a time, giving participants time to express their individual interpretation of each stimulus. We also asked participants to say whether each sentence made sense to them or not and give their interpretation to it. The sentences used in this experiment were the same sentences used in the eye-tracking experiment, however, participants were given a different list from the one they had read before, so they had to interpret different sentences from the ones they had seen during the eye-tracking experiment. The sentences presented were cut short after the target region: “Laura affirmed that the detective was a pig”; “We heard that Joe’s surgeon is a butcher”. There was a time gap of at least seven months between the eye-tracking and the Sentence Interpretation experiment.

5.4.4 Hypothesis

We hypothesised that patients would make literality and concreteness mistakes (Iakimova et al., 2005) when giving their interpretation of the metaphorical sentences. Literality mistakes would be mistakes such as “It’s common place nowadays that adults are to be in touch with their inner child” for the interpretation of “It’s obvious that some adults are babies” or “He’s got enough legs to keep the balls out” for the interpretation of “Luckily, the goalkeeper was a centipede.” In these cases, the expression is interpreted in its primary (literal) meaning. A concreteness mistake would be “They’ve been having fun together” for “Apparently the love affair is a rollercoaster” (all these examples were extracted from participants’ own answers). In these cases, patients expressed a secondary meaning related to the vehicle, but not the context-appropriate one.

5.4.5 Sentence Interpretation Task Results

Table 24 provides an overview of patients' performance in the sentence interpretation task. Paired samples *t*-tests revealed significant differences between the percentage of number of mistakes in the metaphor and literal conditions, $t(24) = 2.67$, $p < .05$, with more mistakes in the metaphorical sentence interpretation. Also, we found significant differences between the literal and nonsensical conditions, $t(24) = 2.13$, $p < .05$, with more mistakes against the nonsensical sentences. We did not find significant differences in the percentage of number of mistakes between the metaphorical and the nonsensical conditions, $t(24) < 1$. It should be noted though that there was a lot of variance in the number of errors made amongst patients (see Appendix D), with some of them making eight mistakes in metaphor processing out of 11 items and others 0 mistakes. In summary, patients made more mistakes when interpreting metaphors than when interpreting literal items, but nonsensical sentences were also a source of mistakes. Mistakes in nonsensical sentences could be due to patients failing to inhibit irrelevant activations to the context of the passage. Some of these mistakes included, for the nonsensical item, "Sam is convinced that the chair is a stage": "Chair head of an organisation. He could be on show all the time with other people"; for the nonsensical item, "We heard that Joe's teacher is a butcher": "I think of my cousin. Surprised that he had a teacher that was a butcher" or expanding the context to unrealistic proportions: e.g. for the nonsensical item, "It's obvious that his spoon was his compass": "He used the spoon as a compass."

From the results obtained in the Sentence Interpretation task, we can surmise that the nonsensical effect found in the eye-tracking experiment for patients cannot be entirely due to patients taking their time to recognise the nonsensicality of the sentences. Perhaps, patients also took longer to process nonsensical items when compared to other conditions in the eye-tracking experiment because they were building up on the sentence context and not inhibiting irrelevant activations properly. The results obtained for nonsensical processing in the eye-tracking experiment is likely not entirely due to a proper nonsense effect, but partially to generating extra (idiosyncratic) context or a lack of control of irrelevant activations to the context of the passage.

Table 26: Percentage of errors in the sentence interpretation task – patient and control group

	Literal expressions	*Metaphoric expressions*	*Nonsensical expressions*
Patients	22.7 *(15.1)*	39.2 *(28.2)*	33.6 *(24.1)*
Controls	5.5 *(9.8)*	15.5 *(22.4)*	21.2 *(16.0)*

Note: standard deviations in brackets.

Table 26 also contains the results for the control participants. Control participants made significantly more errors against metaphorical expressions than literal expressions, $t(20) = 2.19$, $p < .050$, and more errors against literal than nonsensical expressions, $t(20) = 3.97$, $p < .001$. The comparison between metaphorical and nonsensical sentences was not significant ($t < 1$). Compared to patients, controls made fewer errors in all conditions, metaphors, $t(44) = 3.11$, $p < .01$; literals, $t(44) = 17.16$, $p = .001$ and nonsensical items, $t(44) = 12.36$, $p < .05$.

Numerically speaking, although both groups displayed significant differences between literal and nonsensical items processing, the difference was larger for the controls (about 4x more errors against nonsensical items) than for the patients (only about 1.5x more errors). This suggests that both literal and nonsensical processing was challenging for patients, while literal interpretation seems straightforward for controls. Interestingly, the finding that controls displayed a much more striking difference between these two conditions was also apparent in the eye-movement analysis.

One unexpected finding was that controls relatively often made errors against the metaphorical interpretation while these same sentences were judged as acceptable by the participants in the pre-test. It might be that the undergraduate population who participated in the pre-test had a somewhat different tolerance for the metaphorical expressions used or were generally better at text comprehension. Participants who took part in the interpretation study were not students and had finished school some time ago, which perhaps could have made an impact on metaphor interpretation accuracy.

To further examine the hypothesis that comprehension skills are linked to metaphor interpretation accuracy, we looked for differences in the GSRT results between control participants who made the smallest percentage of mistakes ($M = 0$) in metaphor processing (N = 8) to another group of controls who made the largest percentage of mistakes ($M = 50.4$; N = 5) in metaphor interpretation. There was indeed a tendency for better comprehenders to make fewer mistakes, though, likely due to the small numbers in the comparison, this did not reach full significance ($t\ (11) = 1.88$, $p < .09$). Correlations results between best GSRT results and mistakes in metaphor processing did not reach significance either ($r = .409$, $p > .313$).

As for the quality of the answers in the sentence interpretation task, mistakes while interpreting metaphor and nonsensical items differed between groups. When making mistakes against metaphor sentences, controls very often said: “Doesn’t make sense.” Patients, on the other hand, would often either give it a literal, concrete or a nonsensical meaning, such as for *It seemed that their family was a mighty fortress*: “They may be talking about animals or their appearance”; for *It is well known that the politician is an actor*: “He isn’t himself”; for *The goalkeeper was a centipede:* “He had many hands, like a centipede, 100 legs”; and for *The world is a stage:* “The stage is there for anyone to step and perform”. In these cases, the hypothesis that patients would make literality or concreteness mistakes when interpreting metaphors was confirmed.

As for mistakes against nonsensical sentences, we found that controls sometimes tried to make sense by using semantic connections that were not acceptable to communicate any reasonable or meaningful information. These interpretations were metaphoric interpretations of the nonsensical expression. Examples of these interpretations were: for *Apparently, the cups were fireflies*: “Someone could have thrown plastic cups out of the window and they looked like fireflies”; for *Tim claims that his connection is a rat race:* “He’s trying to get through to someone and he’s not being successful”; for *Fiona claims that dampness is a virus:* “It spreads, could make sense because viruses spread too”. Controls also interpreted nonsensical items literally, for *Jim said that the machine is a ladder:* “There is a machine and the mechanism was a ladder”; for *Apparently, Joan’s fork was a mask:* “It was covered in food. So, it’s got a mask on it.”

When making mistakes in nonsensical items processing, patients also gave literal interpretations of the nonsense, but sometimes the semantic connections were not very logical. Examples of such cases are: *Sam is convinced that the chair is a stage:* “Chair, head of an organisation. He could be on show all the time with other people”; *According to Rachel, the glass is a snake:* “Doesn’t make sense. Religious thing perhaps. Alcohol could have sexual connotations for a woman”. Patients also gave metaphorical interpretations to nonsensical items: *Ricardo thinks his new chapter is a toy:* “In a sense that he finds it very easy and he’s toying with its ideas”; for *It’s indeed the case that some machines are sharks,* “Kind of makes sense as sharks are unpredictable and dangerous”; for *Jacqueline claims that her train is a fashion show: “*True statements. Sometimes women go on the train dressed up to compete with other women”. Literal interpretation mistakes often referred to patients considering the literal sentence as nonsensical, such as for *Luckily, the insect was a centipede*: “Doesn’t make sense” or metaphorically, for *Apparently, the attraction is a rollercoaster*: “When couples get together, their relationships can be precarious even when they are attracted to one another”. We can say that, when making mistakes, controls presented more logical interpretations of the sentences. Patients’ mistaken interpretations, on the other hand, seemed to be more illogical.

5.5 General Discussion

Results from the Sentence Interpretation task partially supported the findings from the eye-movement experiment that highlighted a qualitative discrepancy between PwS and controls in metaphor processing (see 5.2.6.3. above). The sentence interpretation task revealed that patients processed around 40% of the metaphors either as nonsense or in a literal or concrete way. Patients’ mistaken interpretations in this study are in line with the hyperactivity across the semantic network hypothesis (Kuperberg et al., 2008), which refers to the "loosening of associations" phenomenon, first described by Bleuler (1911) as typical in PwS. The hyperactivity hypothesis can also, to a degree, explain why in about 30% of the cases patients misinterpreted nonsensical stimuli and even made about 20% of mistakes when processing straightforward literal expression, which was not seen in controls. It is worth noting that the patients who participated in this study had been on medication for over 10 years or more and none of them presented thought disorder, which is more commonly associated with loosening of associations and hyperactivity across the semantic network. Hence, we can say that medication has not really helped eradicate this symptom, at least for the participants we tested.

Familiarity could have played a role in making PwS more aware of the metaphorical meanings of a few of the stimuli, but we cannot be certain how familiar the metaphors were to the patients who engaged in the study. In addition, more efficient reading skills might make an impact on a metaphor sentence interpretation task as it is likely that more skilled and experienced readers will have been more frequently exposed to metaphorical language. However, results from this study can only partially support this view, as we only found a borderline significant difference when we compared controls' best GSRT scores and controls' worst GSRT scores according to their accuracy in metaphor interpretation. In addition, and reinforcing these findings, correlation results between the best GSRT results and mistakes in metaphor processing did not reach significance either.

As metaphors and nonsensical items did not display a significant difference in the number of mistakes in the Sentence Interpretation task, both for patients and controls, the results obtained in this task suggest that metaphoric interpretations might have been influenced by the time participants had to interpret the sentence and come up with different and unusual meanings. We suspect that this was mainly the case for the patients, though given their high number of errors for the literal expressions, this need not be a feature of metaphor processing *per se*.

The idea that working memory plays a significant role in context use and context construction (Kuperberg, 2010; Lee & Park, 2005) is supported by the results of the study, as the Flexibility and Working Memory component was the only component that correlated with the metaphor effect. However, this was only observed for the control group. It is possible that cognitive flexibility and working memory might be relevant cognitive functions when metaphor processing is involved. The fact that it was found relevant for controls, but not for patients, only reinforces this idea.

Chapter 6

LOGICAL METONYMY PROCESSING STUDY

6.1 Introduction

As far as general (non-figurative) language processing in schizophrenia is concerned, impairments have often been related to deficits in executive functions (Hoff et al., 1999; Kuperberg, 2010a, 2010b, Lee & Park, 2005), and semantic and contextual integration (e.g. David, Kuperberg & McGuire, 1998; Kuperberg, 2000; Langdon et al., 2002; Sitnikova, Salisbury, Kuperberg, & Holcomb, 2002; Titone, Levy, & Holzman, 2000;).

With respect to executive function deficits, Hoff et al. (1999) suggested impairments in cognitive functioning and verbal working memory in schizophrenia, arising in the first 2 to 5 years after the diagnosis. Kuperberg (2010a; 2010b) and Lee and Park (2005) demonstrated that PwS display working memory impairments, with Kuperberg (2010a; 2010b) arguing that poor executive functioning, which includes poor working memory skills, negatively impacted contextual construction and contextual information use. Wood et al. (2007) speculated that working memory impairments in PwS arise when complex brain interconnections are necessary for patients to perform language tasks. In general, Lee and Park (2005) found that working memory deficits were reported in 124 studies investigating cognitive impairments in schizophrenia and that working memory deficits were present regardless of task modality.

David, Kuperberg and McGuire (2000) and Kuperberg (2000) found that PwS who had thought disorder did not identify violations of the semantic context as accurately as patients who did not display the symptom. In general, thought disorder has been connected to poor cognitive performance in a variety of tasks, including tasks tapping into executive functioning (Kerns & Berenbaum, 2002; Kuperberg, 2010a; 2010b). In general, a deficit in online contextual language processing and use is reported in PwS, with or without thought disorder (Kuperberg, McGuire, & David, 2000). In this sense, PwS may not fully grasp the global context of a text (Kuperberg, 2000; Kuperberg, McGuire, & David, 1998), which might also affect figurative language interpretation.

Research by Kuperberg, Kreher and Ditman (2010), Holcomb, et al. (2002) and Titone, et al. (2000) suggests that PwS are more likely to interpret a word in its more familiar meaning, which can, eventually, lead to difficulties in processing the full context online, with PwS displaying greater difficulties in processing contextual information when the context is unfamiliar.

In the study described in this chapter, which is based on McElree, Frisson and Pickering (2006), we examined how a specific type of figurative language, i.e. logical metonymy, is processed by PwS. Metonymic expressions are more transparent and systematic than proverbs, idioms, and metaphors in the sense that there is a clear semantic relationship between the figurative (metonymic) and literal interpretation. In this type of metonymy, a salient property or aspect of an entity or concept is used to refer to the entity or concept itself. Some examples of the first type, called *lexical* or standard metonymy, can be found in (6-1 – 6-3):

6-1. Allegations of collusion were summarily rejected by *the White House*

6-2. A lot of Americans protested during *Vietnam* (from Frisson & Pickering, 1999)

6-3. The gentleman read Dickens (from McElree et al., 2006)

In (1), *the White House* is used to refer to the president and his entourage, in (2) *Vietnam* is used to refer to the war rather than the country (in fact, part of the Vietnam War was fought in Cambodia), and in (3), reference is made to the books written by Dickens. According to Nunberg (2004), these examples can be considered a form of *deferred reference* (Nunberg, 2004) in that a non-canonical denotation of the expression needs to be accessed or construed (the allegations are not rejected by the WH building and the gentleman didn't read Dickens the person). In order to interpret these kinds of expression metonymically, they need to be integrated with the wider sentential context: the *White House* needs to be interpreted metonymically (place-for-institution metonymy) because the verb *rejected by* needs to be followed by an animate agent, *Vietnam* refers to an event that is protested against (place-for-event metonymy), and *Dickens* needs to metonymically refer to an object (producer-for-product metonymy) because of the verb *read*. In general, for lexical or standard metonymies, there is a predictable path, a "common metonymic convention" (McElree et al., 2006, p. 183), that can be established between the meaning of the word (e.g. Dickens the person) and its referent (e.g. books written by Dickens).

Previous research has shown that this type of metonymy can be processed straightforwardly, without any early costs, when the metonymic interpretation is already established (Frisson & Pickering, 1999)[17] or when there is relevant contextual information that allows a metonymic extension (e.g. after reading that someone named

[17] Though see Lowder and Gordon (2013), for evidence of a processing cost for certain metonymies when used in argument position. However, Bott, Reese, and Frisson (2015), using a speed-accuracy-tradeoff design with Lowder and Gordon's types of stimuli, found similar processing dynamics between the literal and metonymic interpretations of a word.

Needham is a writer, readers can process the expression *read Needham* without much difficulty, see Pickering & Frisson, 2001).

The second type we examined is known as *logical metonymy* (Lascarides & Copestake, 1998; Pustejovsky, 1995). An example can be found in (4):

(4) The gentleman began the book

Just as it is the case for lexical metonymies, logical metonymies involve a deferred interpretation. For a sentence such as (4), the complement *the book* is not interpreted as a mere object, but rather as an event involving this object, as in *reading the book* (for a detailed discussion, see Pylkkanen & McElree, 2007). The source of this deferred interpretation lies in the verb's meaning: verbs such as *begin, finish, continue, start* refer to events and therefore require the complement to be compatible with an event interpretation. When this is not the case, the complement will be "coerced" into the requisite semantic type so that it now can refer to an event, as is the case in the *reading the book* interpretation. There is ample evidence (e.g. Frisson & McElree, 2008; see Pylkkänen & McElree, 2007, for an overview) that this type of operation elicits a processing cost ("coercion cost") in reading. Hence, while both types of metonymy can be seen as examples of deferred reference, they seem to differ in terms of processing.

McElree et al. (2006) provided direct evidence for the idea that these two types of metonymy are dissimilar. They contrasted lexical metonymies, such as (3, repeated below) to logical metonymies, such as (5) and to literal expressions, such as (6).

3. The gentleman read Dickens

5. The gentleman began Dickens

6. The gentleman spotted Dickens

Example (5) is a combination of both types of metonymy. *Dickens* metonymically refers to Dickens' books, while the verb *began* coerces the object reading of book into an eventive reading. They observed a greater processing cost for logical metonymies, while the lexical metonymies did not differ from literal expressions. They explained their result as follows: when the lexical metonymic interpretation is established, this sense can straightforwardly be accessed, possibly via an underspecified meaning. In contrast, a logical metonymic expression requires the reader to engage in more complex processes of "enriched composition" (Jackendoff, 1997; Pustejovsky, 1995) as simple composition, i.e. the simple combination of the lexical representations of words in a syntactic frame, fails. Hence, arriving at a logical metonymic interpretation seems to implicate a greater reliance on context than lexical metonymy does.

The present study employed the same conditions as McElree et al (2006), but is focused on how PwS process metonymy. Since both types of metonymy rely, to a different extent, on contextual information and since PwS have shown a deficit in combining the meanings of words in a text (see above), we expect that PwS will show extra processing difficulties, compared to controls, during the interpretation of both types of metonymy. However, since the interpretation of logical metonymy requires more complex compositional processing than lexical metonymy, the difference between PwS and controls is likely to be more evident for logical metonymies. In addition, given that successful on-line text interpretation involves the use of working memory and other executive functions (e.g. Brown-Schmidt, 2009; Just & Carpenter, 1992), and given that PwS have shown deficiencies in these areas (e.g. Kuperberg & Heckers, 2000; Cassidy et al., 2016), we will examine to what extent these are implicated in metonymy processing.

6.2. Method

6.2.1. Participants

The same patients and controls who took part in the metaphor experiments (see Chapter 2 for details) took part in the metonymy experiments. The same selection procedure as described in Chapter 1 was applied. As was the case for the irony and metaphor experiment, there was a larger sample that took part in the eye-movement stage of the study than in the Sentence Interpretation Task (see below).

6.2.2. Stimuli Pre-Testing

We generated 33 stimuli triplets, based on the design used by McElree et al. (2006). Each triplet consisted of a literal condition, a lexical metonymy condition and a logical metonymy condition (see Table 25). Only the verb that preceded the noun varied across conditions. Names of famous producers (e.g. Shakespeare, Bob Marley, Beethoven, Einstein) were used to avoid problems with participants failing to recognise the connection between the producer and their product.

Frequency of conventional/literal and metonymical interpretations of the names used in the stimuli was assessed using the British National Corpus, a 100-million-word English corpus, and Internet searches. The first 20 classifiable instances for each name were scored in terms of a literal or metonymic interpretation. The names in the corpus were used in the literal sense 90% of the time (range: 65-100%), which, in ordinary language use, demonstrates a preference for a literal over a metonymic interpretation. The frequency of the preceding verb calculated based on N-Watch (Davis, 2005), and the length in number of characters, did not differ across the conditions (*p*s > .10).

The metonymy stimuli were mixed with fillers that contained names of other types of celebrities other than writers, and the stimuli were counterbalanced over three different lists. Only one verb appeared more than once in a specific list, and there were 19 sentences between the repeated verbs.

Table 27: Condition and stimuli examples

Condition	*Example*
Literal	The gentleman spotted Dickens while waiting for a friend to arrive.
Lexical Metonymy	The gentleman read Dickens while waiting for a friend to arrive.
Logical Metonymy	The gentleman started Dickens while waiting for a friend to arrive.

6.3 Experiment 1: Eye-movement-while-reading Task

We used the same apparatus and procedure as for the irony and metaphor eye movement experiments (see Chapter 2 for details). The study was in line with the standards of the ethics committee of the University of Birmingham and was granted its approval.

As was the case in the irony and metaphor eye-movement experiment, the stimuli were divided over three lists, with an equal number of items per condition in each list. Participants only read one version of each item. An equal number of participants read an equal number of lists in each group. The 33 items were intermixed with 114 filler items from different experiments.

6.3.1 Analysis

Items with tracker loss and items for which the preceding context was not processed attentively (i.e. evidence of skimming) were deleted from the analyses (totalling less than 2%). The two regions of interest, target (underlined) and spill-over (in italics) are exemplified as follows: "The gentleman started Dickens *while* waiting for a friend to arrive." Following the same procedure adopted for the metaphor data, the spill-over region was defined as the first word following the target region if longer than 3 characters, otherwise the next two words.

As in the analyses of metaphor processing, the eye movement results were analysed using a linear mixed effects model in R (R Core Team, 2016) and the package lme4, version 1.1-12 (Bates, et al., 2015), checking for effects of Group (PwS vs. control), Condition (Literal, Lexical Metonymy, Logical Metonymy) and the interaction between Group and Condition. Relevant reading measures (First Pass, Regression Path, Regressions In and Total Time) were tested one by one within the model. The same procedure followed for the irony and metaphor analyses was followed for the metonymy analysis (see details in Chapter 2).

Model comparisons using the anova function were used to test main effects of Condition and Group, as well as their interaction. Comparisons for a main effect of Condition were carried out using sum coding. As we were mainly interested in the effect lexical and logical metonymy had on reading, we compared the Lexical and the Logical Metonymy conditions to the Literal condition. Interactions were examined using comparisons between the conditions for each group separately. However, in order to get a more detailed picture of the processing in each group, we included means comparisons even when the interaction was not significant, as the reading times indicated that there might have been subtle differences within each group.

6.3.2. Metonymy Eye-movement Experiment Results

Average reading times for the different reading measures can be found in Table 28. An overview of the analyses can be found in Table 29.

Table 28: Average Reading Times

	Target region			Spill-over region		
	All	Patients	Controls	*All*	Patients	Controls
First Pass						
Lexical Metonymy	*412 (127)*	412 (125)	412 (128)	*327 (102)*	325 (106)	329 (98)
Literal	*403 (124)*	413 (136)	395 (112)	*328 (107)*	328 (119)	328 (94)
Logical Metonymy	*411 (133)*	426 (158)	398 (107)	*320 (99)*	328 (130)	312 (68)
Regression Path						
Lexical Metonymy	*552 (219)*	604 (266)	503 (171)	*414 (164)*	451 (182)	382 (145)
Literal	*575 (222)*	620 (266)	534 (177)	*397 (155)*	397 (151)	397 (158)
Logical Metonymy	*586 (165)*	626 (186)	549 (144)	*448 (167)*	466 (186)	432 (148)
Regressions In						
Lexical Metonymy	*.18 (.17)*	.22 (.18)	.14 (.15)	*.25 (.19)*	.33 (.21)	.17 (.15)
Literal	*.18 (.18)*	.21 (.20)	.15 (.16)	*.23 (.19)*	.27 (.19)	.18 (.18)
Logical Metonymy	*.23 (.15)*	.25 (.17)	.21 (.13)	*.26 (.23)*	.31 (.26)	.22 (.20)

Total Time						
Lexical Metonymy	*582 (249)*	629 (295)	538 (203)	*414 (164)*	448 (195)	383 (132)
Literal	*596 (228)*	648 (262)	548 (193)	*420 (165)*	446 (206)	395 (124)
Logical Metonymy	*658 (266)*	714 (317)	605 (214)	*455 (157)*	490 (188)	423 (125)

Note: Reading times are in milliseconds; regressions data are in percentages. Standard deviations are in brackets

Table 29: Eye-movement analyses

	Target		Spill-over		
	χ^2	**α**	**χ^2**	**α**	
First Pass					
Condition	< 1		< 1		
Group	< 1		< 1		
Interaction	1.19		1.76	> .41	
Literal vs. Lexical-PwS		$t < 1$		$t < 1$	
Literal vs. Lexical-Controls		$t < 1$		$t < 1$	
Literal vs. Logical - PwS		$t < 1$		$t < 1$	
Literal vs. Logical - Controls		$t < 1$		$t = 1.21$	$p > .22$

Regression Path								
Condition	2.09		> .35		3.09		< .21	
Group	2.93		< .09		< 1			
Interaction	< 1				2.48		>.29	
Literal vs. Lexical-PwS		$t < 1$				$t <1$		
Literal vs. Lexical-Controls		$t = 1.54$		$p > .12$		$t = 1.35$		$p > .18$
Literal vs. Logical - PwS		$t < 1$				$t = 1.39$		$p > .17$
Literal vs. Logical - Controls		$t = 1.23$		$p > .21$		$t = 1.77$		$p > .07$
Regressions In								
Condition	7.08		< .03*		1.91		> .38	
Literal vs. Lexical		$t = 1.20$		$p > .23$				
Literal vs. Logical		$t = 2.43$		$p < .02$*				
Group	2.61		> .10		6.65		< .01**	

Interaction	1.06		> .58		2.27		> .32	
Literal vs. Lexical-PwS		*t* < 1		<1		*t* = 1.17		*p* > .24
Literal vs. Lexical-Controls		*t* = 1.53		*p* > .12		*t* < 1		
Literal vs. Logical - PwS		*t* = 1.03		*p* > .30		*t* < 1		
Literal vs. Logical - Controls		*t* = 2.50		*p* < .02*		*t* = 1.42		*p* > .15
Total Time								
Condition	9.32		< .01**		5.68		< .06	
Literal vs. Lexical		*t* = 2.03		*p* < .05*		*t* = 1.49		*p* > .13
Literal vs. Logical		*t* = 3.09		*p* < .01**		*t* = 2.43		*p* < .02*
Group	2.65		> .10		2.67		> .10	
Interaction	< 1				< 1			
Literal vs. Lexical - PwS		*t* = 1.49		*p* > .13		*t* < 1		
Literal vs. Lexical -		*t* = 1.43		*p* > .15		*t* = 1.38		*p* > .16

Controls				
Literal vs. Logical - PwS	$t = 2.15$	$p < .04$**	$t = 1.69$	$p < .10$
Literal vs. Logical - Controls	$t = 2.29$	$p < .03$**	$t = 1.83$	$p < .07$

6.3.2.1 Target Region

A main effect of Condition was found for the Regressions In and the Total Time measures, with logical metonymies requiring extra processing compared to literal expressions. Further analyses (independent samples *t*-tests) indicated that the Regressions In effect was restricted to control participants. In addition, the Total Time measure indicated that lexical metonymies were processed slightly faster than literal expressions, though the means comparisons for each group were not significant. None of the interactions were significant.

6.3.2.2. Spill-over Region

A near-significant main effect of Condition was found for the Total Time measure, with literal expressions processed faster than logical metonymies in the spill-over region, while lexical metonymies and literal expressions did not differ. As most of the lexical metonymical expressions used in the stimuli were familiar ones, we can say that these results corroborate the idea that a familiar metonymic sense can be accessed immediately and without much difficulty by the reader (Frisson & Pickering, 1999). An effect of Group was found for the Regressions In measure, with PwS making more regressions into the spill-over region overall. The interactions did not approach significance.

Overall, logical metonymies took longer to process than both literal expressions and lexical metonymies, replicating the pattern found by McElree et al. (2006). Although PwS showed increased processing times for all conditions compared to controls, the pattern displayed by both groups was reasonably similar.

6.3.3 Logical Metonymy Effect Correlations

To measure the effort participants displayed during logical metonymy interpretation, we subtracted the literal processing times from the logical metonymy processing time results for all eye-tracking measures in both groups. The processing difference in relation to the logical metonymy processing times was identified as the "logical metonymy effect." The results of the logical metonymy effect were then correlated with the components identified in the PCA analysis detailed in Chapter 2. Because we suspected that PwS and controls might differ in their use of cognitive functions when processing logical metonymies, we analysed the two groups separately. Significant correlations results can be found in Table 30. Please note that these analyses were performed on a subset of the eye-tracking participants due to a number of participants not being available for testing in the second stage. The final tally of participants is 46 (25 PwS and 21 controls).

Table 30: Logical metonymy effect correlations with components extracted from PCA

Region	Measure	Component	Pearson score
Patients			
Spill-over	Regression Path	Difficulties in Cognitive Control	*r* = .445*
	Total Time	Errors in Perspective-taking	*r* = .452*
Controls			
Target	Regressions In	Hinting Comprehension	*r* = .495*
	Total Time	Hinting Comprehension	*r* = .473*
Spill-over	Regression Path	Flexibility and Working Memory	*r* = -.500*
	Total Time	Facial Emotion Recognition	*r* = -.527*

Note: Significance level is indicated by stars: *p <.05; **p < .01; ***p < .001.

The logical metonymy effect for the control group in the target region correlated with Hinting Comprehension. Both correlations (with Regressions In and with Total Time) were positive, suggesting that the higher the use of mentalising skills (strongly embedded in this component), the greater the logical metonymy effect in Total Time and the higher the probability of regressions into the target. If you are better at the Hinting Task, you are better at making sense of what someone is trying to say or hinting, and the process of using mentalising skills involves certain cognitive operations, such as moving from one perspective to the other and adjusting to the interlocutor's point of view. These operations require more time; hence, the processing of the logical metonymy takes longer overall and likely requires more regressions into target.

For the spill-over region, controls displayed negative correlations with the logical metonymy effect, both with the Flexibility and Working Memory component and the Facial Emotion Recognition component, suggesting that more effective cognitive flexibility and working memory, as well as more effective facial emotion recognition are associated with smaller logical metonymy effects in the spill-over region. Why this negative correlation in the spill-over? Previous research suggests that logical metonymy interpretation can take time to complete (McElree et al, 2006), it is possible that people with more effective cognitive flexibility and working memory might grasp interpretation faster in the target, not regressing in the spill-over region.

Patients differed from controls in two ways: there was a correlation with the Difficulties in Cognitive Control component and no correlations with the Hinting Comprehension component. The Difficulties in Cognitive Control component relates to a person having difficulties to focus and not being able to control irrelevant activations to perform tasks. It could be fair to say then that cognitive control is a kind of pre-requisite for logical metonymy processing: when less distracted and displaying more effective inhibitory mechanisms, more chances of enriched processing occurring, which would lead to larger logical metonymy effects. However, the effect goes the opposite way in the spill-over, suggesting that larger logical metonymy effects in the spill-over could be associated with more difficulties in cognitive control. Unclear why, but together these results do seem to suggest that Difficulties in Cognitive Control is a relevant component for logical metonymy processing in the patient, but not in the control group, possibly because controls do not experience much difficulty with cognitive control.

In First Pass in the patient group, we found a positive correlation between the Flexibility and Working Memory component (the same component present in the correlation analysis in the control group), but in the opposite direction , which might indicate that patients who are more cognitively flexible and have more effective working memory, might engage more with the text in First Pass and try harder to interpret the logical metonymy, leading to a larger effect.

Lastly, one thing patients and controls did have in common, the use of facial emotion recognition, was negatively correlated with the logical metonymy effect, which suggests that more effective facial emotion recognition skills can be associated with smaller logical metonymy effects, with fewer regressions into the spill-over for patients and shorter overall processing time differences for controls in the spill-over.

As previously mentioned, ToM involves certain cognitive operations (adjustment to the Other perspective) that require time to be completed. In the case of facial emotion recognition, we do not see results pointing to it as a skill that enlarges the logical metonymy effect, on the contrary, it makes it smaller. In this case, these results reinforce the idea that facial emotion recognition is not directly associated with being able to acknowledge another person's perspective (see Chapter 3).

6.3.4 Logical Metonymy Eye-Tracking Results Discussion

Results revealed that both groups found logical metonymies more taxing than literal items while lexical metonymies were processed as fast as literal items (and even somewhat faster in the Total Time measure, see Table 9). Although patients displayed increased processing times for all conditions when compared to controls, patterns presented by both groups were not considerably dissimilar. When we analyse results from correlations between factors extracted from the PCA and the logical metonymy effect, we notice that in the patient group larger logical metonymy effects correlated with flexibility and working memory, difficulties in cognitive control and facial emotion recognition. For controls, difficulties in cognitive control were not correlated with the logical metonymy effect, leading us to speculate that perhaps cognitive control difficulties might eventually be a cognitive marker of schizophrenia.

6.4 Experiment 2: Sentence Interpretation Task

A sentence interpretation task was carried out to establish exactly how participants from both groups processed logical metonymies. Judging from the logical metonymy effect correlation results, it could be the case that PwS had difficulties in properly interpreting the stimuli.

6.4.1 Participants

The same participants engaged in the eye-tracking experiment participated in the Sentence Interpretation task. Again, as in the metaphor experiment, a time gap of at least seven months was kept between the two experiments. However, due to some participants being unable to take part in this stage of the study, the sample is somewhat smaller (PwS: 25, controls: 21).

6.4.2 Stimuli

Similarly to the metaphor experiment, we used the same stimuli as in the eye-tracking experiment; and again, participants were given a different list from the one they had received in the eye-tracking experiment. For example, if they had seen an expression in the logical metonymy condition during the on-line reading task, it was now used in a literal condition.

6.4.3 Procedure

The same procedure used for the irony and metaphor sentence interpretation task was used (see details in Chapter 3). We hypothesised that patients would be more likely to find logical metonymies to be senseless, as they would tend to consider the literal interpretation of the coercion involved in the logical metonymies, not the figurative one. We did not expect major problems in lexical metonymy processing for patients as they did not show any major differences in reading times compared to the literal condition.

6.4.4. Sentence Interpretation Task Results

Paired Samples *t*-tests revealed significant differences between patients and controls in all conditions. Patients made significantly more mistakes when processing literal expressions, lexical metonymies and logical metonymies when compared to controls (lexical metonymies, $t(44) = 2.73$, $p < .008$; literals, $t(44) = 5.35$, $p = .001$ and logical metonymies, $t(44) = 6.93$, $p = .001$).

Table 31: Percentage of errors in the sentence interpretation task – patient and control group

Group	*Literal - Mean (SD)*	*Lexical Metonymy - Mean (SD)*	*Logical Metonymy - Mean (SD)*
Patient	*22.1(7.42)*	*4.52(16.12)*	*30.52(17.08)*
Control	*1.98(1.98)*	*1.81(1.81)*	*8.72(8.72)*

We examined patients' explanations[18] of the literal sentences where their judgment was inaccurate, and we found that the mistakes were related to: a) failure to acknowledge that a verb that is regularly used with living people as complements can be used with dead people as complements ("The archbishop decided to contact da Vinci" – "Doesn't make sense, da Vinci is dead"; "The young physicist could always phone Einstein" – "Doesn't make sense, Einstein is dead"; "The educated slave greeted Aristotle" – "Nonsense"); b) failure to acknowledge that a less typical literal construction can still make sense ("The book company's decision to hire J.R.R. Tolkien…" – "Unfinished and doesn't make sense"; "The scientist wrote Stephen Hawking" – "Nonsense"; "The record producer decided to photograph Rihanna" – "Doesn't make sense, he's a producer, not a photographer"). In the cases highlighted here, less typical literal constructions were involved. We assume that less typical literal sentences led to processing errors in the patient group. Patients seemed to display more restricted lexical combination interpretations when compared to controls or they tended to stick to the most typical lexical combinations, judging unusual, but still plausible lexical combinations as nonsense. This could have had an impact on their recognition of a literal sentence's plausibility. In addition, as in this experiment, participants were not given more contextual information (the sentence was read only up to the target region) and references to deceased people could not be clearly established in a historical context, it could have made it harder for patients to fill in the gaps and come up with appropriate interpretations, although this did not seem to be a problem for controls. It is surprising, though, that this relatively high percentage (22%) of misinterpretations or rejections of a literal interpretation was not reflected in the eye movement record, as patients, when compared to controls, did not significantly

[18] All examples in the following paragraphs come from patients' actual answers in the test.

differ in their on-line processing times for literal sentences. A possible explanation for the literal processing difficulty for patients in the sentence interpretation task, is that patients find literal expressions non-sensical only when given less contextual information and/or enough time to consciously reflect on them, as was the case in the sentence interpretation task.

As for errors in conventional metonymy processing among patients, we found that they sometimes failed to recognise the plausibility of less frequent lexical combinations, such as in the case of “The philanthropist published T.S. Eliot” – “Nonsensical. A philanthropist cannot be a publisher” and they sometimes also failed to recognise less typical producer-product relationships in metonymic sentences such as “The music student wished he could conduct Beethoven” – “No, doesn’t make sense. Beethoven lived a few hundred years ago and you can’t conduct a person”; “The bilingual neighbour wanted to translate Anne Frank” – “Doesn’t make sense, you can’t translate a person”; “The editor published Wittgenstein” – “The editor would publish Wittgenstein’s works. That would make sense”. In these cases, less typical lexical combinations are not selected as plausible. However, it should be noted that on average, lexical metonymies were quite well accepted by both groups (in about 95% and 98% by patients and controls respectively). Patients could easily interpret sentences such as “The gentleman read Dickens” – “Self-explanatory. He read a book by Dickens”; “The archbishop decided to display da Vinci” – “Makes sense. He had a painting by da Vinci and decided to display it”; “In order to relax, he used to enjoy Bob Marley” – “Makes sense. Listening to Bob Marley’s music, smoking while listening to the music and relaxing”.

Finally, errors in logical metonymy processing were more frequent than errors in any other condition (31% for patients, 9% for controls). Mistakes in logical metonymy interpretation were: a) failed attempts to fill the gap and build a correct sense for the logical metonymy in the sentence, “The company decided to no longer delay Pavarotti” – “They could have been a promotional company, they were delaying the concert and they decided not to do it anymore”; “Astronomers in the eighteenth century completed Newton” – “He was a separate person, so I think it’s in his infancy in the 10th century, the study of stars and planets”; b) sentences were considered unfinished and nonsensical, “It’s a fact that the company that decided to delay J.K. Rowling…” – “Doesn’t make sense, they are not specifying what”; and c) sentences were deemed nonsensical sometimes due to a perceived mismatch between complement and verb, “According to music industry rumours, they had re-released Elvis Presley” – “You can only re-release his songs. Nonsense”; “Astronomers in the 18th century developed Newton” – “Nonsense”; “The bilingual neighbour wanted to begin Anne Frank” – “Nonsense”; “The young physicist could always master Einstein” – “Doesn’t make sense. Einstein is a person, not art or something like that”; “According to music industry rumours, they had resumed Elvis Presley” – “No, doesn’t make sense. Elvis Presley is a person. You can’t resume Elvis Presley”.

Again, when we look at the errors in logical metonymy processing, we find that typicality seems to play a role. More typical combinations in logical metonymical sentences did not lead to errors, “The company decided to no longer distribute Pavarotti” – “They didn’t want to sell his music anymore”; “The philanthropist finished T.S. Eliot” – “Makes sense. The philanthropist finished reading a book by T.S. Eliot”; “The student continued Sartre” – “It makes sense. He continued reading Sartre”; “The gentleman started Dickens” – “He started reading Charles Dickens”. Although we cannot be precise in relation to the degree of familiarity of the logical metonymy sentences, we can see that it is likely that less typical lexical combinations were considered nonsensical and their figurative meanings were not possible to be perceived. Still, looking at Table 7, we can observe that patients' performance in the metonymy interpretation task varied, unlike controls' performance, which was very steady.

Finally, we also examined whether the severity of positive and negative symptomatology had a connection with accuracy in logical metonymy processing. Results indicated that in the sample studied there were no significant correlations between positive or negative symptomatology and accurate logical metonymy processing, although we found a borderline positive correlation between positive symptomatology and the number of mistakes in logical metonymy processing (r = .340, n = 25, p = .096), suggesting that perhaps, with a larger sample, this result could have become significant. However, with the results obtained in this study, we cannot fully support the idea that more severe positive symptoms in a patient diagnosed with schizophrenia could be linked to poorer performance in logical metonymy interpretation. It is remarkable that although PwS that took part in this study had been on medication for a long time, they still could not process logical metonymies or even literal sentences as accurately and straightforwardly as controls.

6.5 General Discussion

The first striking finding we came upon was a significant difference in the number of mistakes between the two groups for all conditions in the sentence interpretation task. Patients displayed more difficulties in processing lexical metonymies, logical metonymies and literal items, although the greatest difficulty was in logical metonymy processing. Controls did not show many difficulties in the interpretation task. In fact, when looking at Table 13 in the Appendix E, only one control participant made some errors against all conditions (mainly the logical metonymy condition), while for all other control participants no mistakes were observed for any of the sentences. It is unclear why this participant behaved differently.

The results for the sentence interpretation task confirmed that around 30% of the logical metonymy fragments in the stimuli were processed as nonsensical or unfinished sentences by patients, which did not become clear in the results obtained in the eye-tracking experiment. Although the metonymy eye-tracking experiment did not reveal striking differences between groups, it revealed that there was still a cost for logical metonymy processing when eye movements were recorded. For the control group the extra processing effort displayed for logical metonymies could not be explained by inaccurate understanding, as controls did not make mistakes in literal processing (except for one participant). The eye movement results are in line with previous research showing that logical metonymies are more taxing to process than literal expressions (e.g. Frisson & McElree, 2008; McElree et al. (2006), Traxler, McElree, Williams & Pickering, 2005). The finding that logical metonymies and literal expressions were equally well understood by control participants, together with the fact that controls did not have their logical metonymy effect correlated with errors or difficulties in any cognitive function embedded in the components, supports the idea that deferred interpretation *per se* does not reflect difficulties in interpretation (see also McElree et al., 2006).

Logical metonymy processing had a cost for both patients and controls and patients displayed a tendency to read all conditions more slowly. For the patient group only, longer processing times in the spill-over region suggested that difficulties in using cognitive functions, such as cognitive control might be at play. Hence, these results indicate that logical metonymy processing, i.e. establishing an enriched interpretation of an expression such as *The gentleman started Dickens*, can be relatively straightforward to the neurotypical reader, although with a processing cost. For PwS, on the other hand, it can be challenging.

It is notable that difficulties in cognitive control among PwS correlated with the Regression Path measure both in the target and in the spill-over region, which suggests that this function could be a primary requirement for a person to access the figurative meaning implied by logical metonymies and ironies, with more regressions into the spill-over region in Regression Path (see Chapter 4). Cognitive control difficulties did not seem to be an issue for controls, as this component did not correlate with any logical metonymy effect for this group. We can speculate that control participants more easily make use of cognitive control, which makes it not an obstacle for the figurative meaning processing to happen. For controls, more difficulties in flexibility of thought, working memory and facial emotion recognition made them display more overall regressions in the spill-over region. It seems that functions such as flexibility of thought and working memory might need to be recruited for proper logical metonymy processing among the neurotypical population.

Results from this study showed that logical metonymies can be more easily interpreted when cognitive control (as a primary function), flexibility, working memory and facial emotion recognition are activated. In addition, this study showed that it is likely that patients and controls might not process logical metonymies in exactly the same way. The Sentence Interpretation Task results revealed 30% of errors in logical metonymy processing, which was not found among controls. Literal processing also revealed that PwS and controls differed, with patients displaying 22% of errors in this condition, again different from controls. Apparently, patients and controls do not seem to understand logical metonymies in quite the same manner but neither do they seem to do that for literal expressions. Lexical metonymies didn't seem to present a real processing issue for patients, which might indicate that lexical metonymies are perhaps more lexicalised figurative items, not requiring supplementary cognitive effort.

7. General Thesis Summary and Discussion

The present thesis aimed at answering questions regarding cognitive functioning in people with schizophrenia (PwS) who have been on a long course of second-generation anti-psychotics. My research found that even after at least 10 years of medication, some cognitive mechanisms in PwS remained discrepant compared to neurotypical controls. The disparity in cognitive skills, or at least in the use thereof, between PwS and controls related to cognitive control, flexibility of thought, working memory and some aspects of theory of mind (mainly the perceived difficulty to do the tasks, the time taken, and a default self-centred perspective). This research also found out that these deficits interacted with figurative language processing, making understanding figurative language more taxing for PwS than for controls. Eventually, PwS tested often interpreted figurative utterances in a literal or concrete way, suggesting that perhaps literality and concreteness are not only related to poorer ToM skills, but also to poorer flexibility of thought, poorer working memory and difficulties in cognitive control.

The results obtained in the cognitive tests administered in two separate batteries highlighted that the patients who took part in this research had similar verbal IQs and reading skills when compared to neurotypical controls (first battery). However, patients' performance in cognitive control, flexibility of thought, including time to change the train of thought, time to perceive hints in a conversation, difficulty in identifying hints, hint identification accuracy and number of errors in judging inconsistent "Other" trials significantly differed from controls (second battery). Such discrepancies suggest deficits in these functions.

Being aware of the possible cognitive impairments present in the patient group, we extracted the figurative language effect for irony, metaphor and logical metonymies to see whether the figurative language effect would display any correlations with the components extracted from the PCA analysis which included the variables from the second battery of cognitive tests. We found out that, in fact, the functions from the second battery did correlate with the figurative language effect for both patients and controls, but not necessarily in the same way.

As for differences in perspective-taking skills, results revealed that errors in perspective-taking for controls when judging the "Self" perspective were associated with difficulties in mentalising and in cognitive control. More effective facial emotion recognition was also connected with fewer errors in judging the "Other" perspective in inconsistent trials for controls. Additionally, more effective flexibility of thought, working memory and mentalising skills seemed to improve judgment accuracy of the "Other" perspective for both groups. These results suggest that mentalising and cognitive control are relevant cognitive functions for perspective-taking.

One of the most interesting results found in the research that concerns ToM was the fact that, unlike controls, patients did not display the intrusion of the "Other" perspective when judging the "Self" perspective. This finding has implications to ToM function in schizophrenia. It seems that although patients and controls could perform with relatively similar accuracy in the Perspective-taking task, still, the pattern of mistakes made by both groups was very different.

In fact, patients displayed an intrusion of the "Self" when judging the "Other" perspective, which we can call a "self-reference effect", while controls displayed an intrusion of the "Other" when judging the "Self" perspective, as if controls were tuned in with the "Other" perspective more than they were with their own perspective, while patients were tuned in with their own perspective more than with the "Other" perspective. It seems that patients had to make an extra effort to tune in to the "Other" perspective and the fact that patients were significantly slower than controls when evaluating the "Other" perspective only reinforces this idea. Adjustments to the "Other" point-of-view can apparently be taxing for patients.

Patients in partial remission did not display any differences in hinting comprehension accuracy in relation to controls, but they still found hinting comprehension significantly more taxing than controls and they took significantly longer to do the task, which suggests that remission can improve accuracy in mentalising, but does not make it a lot more straightforward for these patients. Perhaps, if these patients had perhaps more effective working memory skills or cognitive control and flexibility skills, they could benefit more from the remission stage and mentalising would become easier. Overall, however, excluding patients in partial remission, the patient group as a whole displayed significant differences in accuracy for the Hinting Task. Perhaps mentalising is a cognitive function that is most difficult to recuperate, even after a long and regular course of anti-psychotic medication.

The organisation of the variables within the components suggested that facial emotion recognition, differently from mentalising skills, did not cluster in the same component as perspective-taking, indicating that facial emotion recognition is an autonomous skill, not recruiting the same type of ToM processing as mentalising and perspective-taking. Because we tested outpatients who had been on second-generation anti-psychotic medication for more than 10 years, and these patients did not present a facial emotion recognition impairment in relation to neurotypical controls, it would be fair to say that an impairment in facial emotion recognition might not be permanent for PwS. Hence, it cannot be considered a trait of the disorder, as suggested by Rohler et al. (2009).

The present thesis was able to disclose that poor processing of figurative language can still be present in PwS, even after more than 10 years on a steady course of second-generation anti-psychotic medication. This suggests that it is a real symptom of the disorder, although possibly only present to the extent of the impairment in the cognitive functions mentioned above. While the poor performance on figurative language understanding was most clear when patients were asked directly about their interpretation and were given ample time to respond (cf. sentence interpretation tasks, see Chapters 4, 5 and 6), there were already some subtle differences during their on-line processing as well. Interestingly, this research also indicated that when running eye-movement experiments related to language processing among PwS, it is advisable to double check interpretations by also running sentence interpretation experiments. This is mainly because the time spent on specific regions might not significantly differ in comparison with neurotypical controls, but interpretations might differ. In fact, one of the surprising findings was that the reading times between patients and controls only showed small differences, while the results of the interpretation tasks revealed quite substantial differences between the two groups.

Another interesting finding this research was able to produce was the fact that not only PwS, but also some controls, could present some degree of literality or concreteness, depending on how effective cognitive functions such as flexibility of thought, working memory and cognitive control were for these participants. Overall, however, control participants did not present considerable problems in these functions, as their performance in the sentence interpretation task was significantly more accurate than PwS's.

It is worth noting that, during eye-tracking, participants read to and for themselves and are not really in a communicative setting. In contrast, during the sentence interpretation task, there was a live interaction with another person (the experimenter), and the participants had to take into account what the interlocutor was saying and evaluate its content in order to assess whether what the interlocutor said made sense, how it could be interpreted, and then tell the experimenter how they assessed what they had been told. This requires some degree of ToM and, as we found in the ToM experiments (and as shown frequently in the literature, e.g. Corcoran et al., 1995; Pickup & Frith, 2001), patients struggle more with understanding other people's perspective. Hence, as patients tend to have a more self-centred perspective (see Chapter 3), it can become more difficult to understand the interlocutor's utterance in a conversation. These factors might have contributed to the discrepancy identified in the results between the on-line and off-line tasks.

As for irony processing, the results revealed that familiar ironies did not display early processing differences in relation to their literal counterparts; however, there was a cost for irony processing in later reading measures. This study supports evidence from familiar sarcasm data (Turcan & Filik, 2016). A possible explanation for these findings is that both literal and ironic interpretations are retained (e.g. Giora, 1995; 1997), to be later resolved through contextual integration, which is expected to require longer processing when reading.

The relevant cognitive functions associated with the irony effect were facial emotion recognition, flexibility of thought, working memory and ToM. Our results, following previous ones (Spotorno et al., 2012; 2013), indicated a connection between mentalising skill and irony processing. The fact that for controls irony processing activated mentalising functions at early reading stages, such as First Pass, corroborates previous findings that ToM activations are recruited at early stages of irony processing (Spotorno et al., 2013).

Correlations between the components and the irony effect in the patient group did not reach significance; however, although only borderline significant, it became apparent that there was a higher probability of regressions into the spill-over region related to more difficulties in cognitive control and lower scores in the Hinting Task in this group. Cognitive control, as well as ToM, seem to be two major cognitive functions for irony processing and the tendencies displayed in the patient group data only reinforce this idea.

Judging from the results obtained for irony processing, both in the eye-tracking experiment and in the sentence interpretation experiment, better accuracy in irony processing tends to require longer processing times and, thus, a larger irony effect.

Control data support this idea, as controls, showing increased processing times for ironies compared to literal expressions, had a significant larger accuracy rate in the sentence interpretation task when compared to PwS.

In fact, patients processed the literal counterpart of the ironic expressions just as accurately as controls, which suggests that the literal counterpart of the ironic expression sounds straightforward to patients, as the contradiction present in the ironic remark is absent in its literal counterpart. Results for the literal counterparts in relation to the ironic expressions suggest that literal versions of ironic expressions are very straightforwardly interpreted by PwS.

It is striking that although patients had as much time as they needed to process the ironic sentences in the sentence interpretation task, they, in 42% of the cases, did not arrive at an accurate interpretation, finding the expression contradictory and/or senseless. If we are to compare the results from the eye-tracking experiment and the results obtained from the sentence interpretation task, we must be cautious, as participants, having more time to come up with an interpretation for the passage, can start providing idiosyncratic interpretations that are not relevant for the context. Idiosyncratic interpretations are not easily determined by eye-tracking measures. Hence, it remains unclear whether the patient eye-tracking data reflect a correct ironic interpretation or not and whether the high number of interpretation errors seen in the interpretation task is the result of unrestricted processing time.

On the other hand, although the eye-tracking results for the irony study did not reveal dramatic differences between patients and controls, the correlations with the PCA components revealed more substantial discrepancies between the two groups, showing that perhaps patients don't even recruit the relevant cognitive functions involved in irony processing, making accuracy even more distant for patients than for controls. This would suggest that even though the eye-tracking data in itself might not directly reflect a problem in irony processing for patients, the correlational results suggest that whatever interpretation they achieve on-line, the cognitive mechanisms they used differed from controls.

As for metaphor processing, our findings revealed more of a qualitative discrepancy between groups rather than a quantitative discrepancy. Qualitative discrepancies refer to the cognitive functions used by controls (flexibility of thought and working memory) while processing metaphors, functions that did not seem to be employed in the same way or to the same extent by patients. Additionally, patients in the sentence interpretation task in the metaphor study processed around 40% of the sentences either in a literal or concrete and nonsensical way, which was not revealed by the eye-movement measures alone. In this sense, the irony and metaphor concurred in that the most explicit differences between patients and controls were found in the off-line data while on-line processing differences were mainly apparent when related to cognitive skill rather than reading times per se.

The nonsensical stimuli used for the metaphor study engendered idiosyncratic explanations from patients in about 30% percent of the cases. Literal counterparts of the metaphoric expression also were not very straightforward, generating about 20% of misinterpretations. This phenomenon was not displayed by controls' results. It is worth noting that patients recruited for this study did not present thought disorder, a symptom that is known for relating to semantic network hyperactivity and loosening of associations (Kuperberg, 2008). Hence, we can say that medication has not been able to eradicate cognitive flexibility and working memory problems to make patients' language processing more effective and accurate.

Familiarity might have played a role in patients' understanding of metaphoric sentences, although we have no data on how familiar the metaphoric stimuli were to patients who participated in the study. In addition, the fact that more experienced readers often have the opportunity to encounter metaphorical language, it is possible that patients who were more often engaged in reading found interpreting metaphors a more straightforward process, though this remains to be investigated further.

As the Flexibility and Working Memory component was the only one to correlate with the metaphor effect, and only in the control group, not in the patient group, the metaphor eye-tracking study results support the idea that working memory plays a significant role in context use and context construction (Kuperberg, 2010; Lee & Park, 2005), The fact that significant differences appeared only between literal and nonsensical items in the eye-tracking experiment reinforces the findings from the sentence interpretation task results, which suggested no significant differences in accuracy between metaphors and nonsensical items. This is an interesting finding, as one task results confirmed the other task results pointing out that metaphors and nonsensical items were in fact very similarly processed as far as accuracy (or lack thereof) was concerned.

The sentence interpretation results for the metonymy experiment revealed a significant difference in number of mistakes between patients and controls for all conditions. This means that patients displayed more difficulties in processing lexical metonymies, literals and logical metonymies when compared to neurotypical controls. Logical metonymies revealed the most dramatic differences, but all three conditions seemed to have had a low accuracy rating for patients. Controls, on the other hand, did not have many difficulties when interpreting the items from the sentence interpretation task. In fact, in the sentence interpretation task, around 30% of the logical metonymy stimuli were interpreted incorrectly either as unfinished or as nonsense by the patients, while controls made less than 9% errors for this condition. These results were not clear in the eye-tracking experiment, as they only revealed a cost for logical metonymy processing overall.

As controls only made few mistakes in the sentence interpretation task while interpreting logical metonymies, it would be very unlikely to attribute the processing cost found in the eye-tracking experiment to inaccurate understanding. Previous research had also highlighted that logical metonymies are more taxing to be processed than their literal counterparts (Frisson & McElree, 2008; McElree et al., 2006; Traxler, McElree, Williams & Pickering, 2005). Results obtained in the logical metonymy sentence interpretation task study support the idea that deferred interpretations (coercions) do not impose obstacles to interpretation, at least for neuro-typical controls.

The metonymy eye-tracking study results highlighted that difficulties in cognitive control, flexibility and working memory, and facial emotion recognition could be relevant for logical metonymy processing. However, the cognitive control function only appeared correlated with the logical metonymy effect in the patient group. For neurotypical controls, as they did not display correlations between the logical metonymy effect and difficulties in cognitive control, this component does not seem to be implicated in their processing of logical metonymies. Finally, results from this research indicate that logical metonymies can be more accurately interpreted when inhibitory skills are at play, and when flexibility, working memory and facial emotion recognition are recruited.

The small number of participants (both patients and controls) is a limitation of the present study. This is especially relevant for patients, who showed more variability. Another limitation of this research is the fact that the correlational findings can only be exploratory considering the small number of participants in the study (which is also why we did not correct for multiple comparisons). A greater number of participants would possibly have granted stronger grounds for our findings.

The advantage of studying the cognitive correlates underlying figurative language processing in schizophrenia, and not only the psychiatric symptoms that correlate with figurative language comprehension impairment, is the fact that psychiatric symptoms are in themselves entities that only describe pathological behaviour, not clarifying the underlying causal mechanisms that are involved in symptom manifestation. Research on the cognitive correlates underlying the difficulties presented by PwS can be more fruitful for engendering possible treatments for the disorder.

Since anti-psychotic medication acting upon the dopamine receptors in the brain hasn't been able to provide a better prospect for patients or a better integration for them in the community, not to mention that some patients do not even report a decrease in their positive and negative symptomatology, it is worth finding out whether cognitive therapy dedicated to the development of alternative synapses could help patients recover some of their cognitive functions, especially cognitive control, flexibility of thought and working memory. Although PwS do seem to present decreased neuronal density, neuronal size and neuropil (axons, dendrites and glia), causing an apparent reduction in the grey matter in these patients (Boska, 2010), it could still be worth trying to develop alternative cognitive therapy tackling the decline of the above-mentioned functions, at least in children at risk of developing schizophrenia.

The ability to understand figurative utterances is relevant for social interaction and could help patients with schizophrenia integrate better in the community. Maybe, the development of future therapeutics to tackle cognitive deficits in cognitive control, flexibility, working memory and ToM could result in PwS performing more accurately in everyday language use, especially when the meaning is less straightforward, as might be the case in figurative language.

REFERENCES

Addington J, Addington D. (1998). Visual attention and symptoms in schizophrenia: a 1-year follow-up. *Schizophrenia Research* 34: 95-99.

Addington, D., Addington, J., & Maticka-Tyndale, E. (1993). Assessing depression in schizophrenia: The Calgary Depression Scale. *The British Journal of Psychiatry, 163(Suppl 22)*, 39-44.

Asgharpour, M., Tehrani-Doost, M., Ahmadi, M.& Moshki, H. (2015). Visual Attention to Emotional Face in Schizophrenia: An Eye Tracking Study. *Iranian Journal of Psychiatry*, *10(1):* 13–18.

Aitken, L., Daly, C., Soni, S. (1993). Cognitive dysfunction in schizophrenic patients. *Schizophrenia Research, Vol. 9, Issues 2-3*, Page 171.

Akbarfahimi, M., Tehrani-Doost, M., Ghassemi, F. (2013). Emotional Face Perception in Patients with Schizophrenia: an Event-Related Potential Study. *Neurophysiology, Vol. 45, Issue 3:* 249–257.

Aloia, M. S., Gourovitch, D., Missar, D., Pickar, D., Weinberger, D. R., & Goldberg, T.E. (1998). Cognitive substrates of thought disorder II: Specifying a candidate cognitive mechanism. *The American Journal of Psychiatry 155(12)*, 1677-84.

Anderson, J.R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behaviour 22*, 261-95.

Apperly, I. A., Carroll, D. J., Samson, D., Humphreys, G. W., Qureshi, A., & Moffitt, G. (2010). Why are there limits on theory of mind use? Evidence from adults’ ability to follow instructions from an ignorant speaker. *Quarterly Journal of Experimental*

Psychology, 63: 1201–1217.

Apperly, I. A. (2012): What is “theory of mind”? Concepts, cognitive processes and individual differences, *The Quarterly Journal of Experimental Psychology, 65:5*, 825-839.

Barch, D. M.; Cohen, J. D., Servan-Schreiber, D., Steingard, S., Steinhauer, S., & Van Kammen, D. (1996). Semantic priming in schizophrenia: An examination of spreading activation using word pronunciation and multiple SOAs. *Journal of Abnormal Psychology 105*, 592-601.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68(3):* 10.1016.

Baron-Cohen, S., Leslie, A. M., Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition, 21*: 37–46.

Bates, D., Maechler M., Bolker, B. Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48.<doi:10.18637/jss.v067.i01>.

Benjamin, J. (1944). A method for distinguishing and evaluating formal thinking disorders in schizophrenia. In Kasanin, J. (Ed.), *Language and Thought in Schizophrenia* (pp.65-90). University of California Press, Berkeley.

Birch, S.A.J., & Bloom, P. (2004). Understanding children’s and adults’ limitations in mental state reasoning. *Trends in Cognitive Sciences*, *8*: 255–260.

Bleuler, E. (1911). *Dementia Praecox oder Gruppe der Schizophrenien*. Deuticke, Leipzig.

Bleuler, E. (1966). *Dementia Praecox or the Group of Schizophrenias*. International Universities Press.

de Bonis M, Epelbaum C, Deffez V, Féline A. (1997). The Comprehension of Metaphors in Schizophrenia. *Psychopathology,30:*149-154.

Boska P. (2010). Effects of prenatal infection on brain development and behaviour: a review of findings from animal models. *Brain, Behavior and Immunity;24*:881–97.

Bošković M, Vovk T, Kores Plesničar B, Grabnar I. Oxidative stress in schizophre

Bora E., Yucel M., Pantelis C. (2009). Theory of mind impairment in schizophrenia: meta-analysis. *Schizophrenia Research, 109(1-3):*1-9.

Bošković M, Vovk T, Kores Plesničar B, Grabnar I. Oxidative stress in schizophrenia. Curr

Bowie, C. R., Reichenberg, A., Patterson, T. L., Heaton, & Harvey, P. D. (2006). Determinants of real-world functional performance in schizophrenia subjects: correlations with cognition, functional capacity, and symptoms. *The American Journal of Psychiatry, 163*, 418-425.

Buchy, L., Woodward, T. S., & Liotti, M. (2007). A cognitive bias against disconfirmatory evidence (bade) is associated with schizotypy. Schizophrenia Research, 90(1–3), 334–337.

Brown-Schmidt, S. (2009). The role of executive function in perspective taking during online language comprehension. *Psychonomic Bulletin & Review*, Vol. 16, Issue 5: 893–900.

Brüne, M. & Bodenstein, L. (2005). Proverb comprehension reconsidered – 'Theory of Mind' and the pragmatic use of language in schizophrenia. *Schizophrenia Research. 75*: 233-9.

Brűne, M., & Bodestein, L. (2005). Proverb comprehension reconsidered: "theory of mind" and the pragmatic use of language in schizophrenia. *Schizophrenia Research*, *75*(2-3), 233-239.

Carlson, S. M., Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development., 72*:1032–1053.

Carter C. S., Robertson L.C., Nordahl T.E., Chaderjian M., Oshora-Celaya L. (1996). Perceptual and attentional asymmetries in schizophrenia: further evidence for a left hemisphere deficit. *Psychiatry Research*, *May 17;62(2)*:111-9.

Cassidy, C. M., Van Snellenberg, J. X., Benavides, C., Slifstein, M., Wang, Z., Moore, H., Abi-Dargham A., Horga, G. (2016). Dynamic Connectivity between Brain Networks Supports Working Memory: Relationships to Dopamine Release and Schizophrenia.. Journal of Neuroscience 13, 36 (15): 4377-4388.

Chaika, E. (1974). A linguist look at 'schizophrenic' language. *Brain & Language, 1*, 257-76.

Cohen, J. D., & Servan-Schreiber, D. (1992). Context, cortex and dopamine: A connectionist approach to behavior and biology in schizophrenia. *Psychological Review, 99*, 45-77.

Cohen, J. D., Barch, D. M., Carter, C. & Servan-Schreiber, D. (1999). Context processing deficits in schizophrenia: Converging Evidence From Three Theoretically Motivated Cognitive Tasks. *Journal of Abnormal Psychology, 108, n. 1,* 120-133.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review, 82*, 407-28.

Condray R., van Kammen, D. P., Steinhauer, S. R., Kasparek A., Yao, J. K.(1995). Language comprehension in schizophrenia: trait or state indicator? *Biological Psychiatry, Sep 1;38(5):*287-96.

Corcoran, R., Mercer, G., & Frith, C. D. (1995). Schizophrenia, symptomatology and social inference: Investigating theory of mind in people with schizhophrenia. *Schizophrenia Research, 17,* 5-13.

Corcoran, R. & Frith, C. D. (2003). Autobiographical memory and theory of mind: evidence of a relationship in schizophrenia. *Psychological Medicine, 33(5):* 897-905.

Cornblatt, B. A., & Keilp, J. G. (1994). Impaired attention, genetics, and the pathophysiology of schizophrenia. *Schizophrenia Bulletin, 20,* 31-62.

Covington, M., He C., Brown, C., Naci, L.¸ McClain, J., Fjordbak, B., Semple, J., & Brown, J. (2005). Schizophrenia and the structure of language: The linguist's view. *Schizophrenia Research, 77*, 85– 98.

Crone et al. (2005). Neurocognitive development of the ability to manipulate information in working memory. *PNAS*, *103*, 24.

David, A., Kuperberg, G., McGuire, P. K. (1998). Reduced sensitivity to linguistic context in schizophrenia thought disorder: evidence from online monitoring for words in linguistically-anomalous sentences. Journal of Abnormal Psychology 107, 423-34.

De Grauwe, S., Swain, A., Holcomb, P. J., Ditman, T., & Kuperberg, G. R. (2010). Electrophysiological insights into the processing of nominal metaphors. *Neuropsychologia, 48*, 1965–1984.

Diamond, A., Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "Do as I say, not as I do". *Developmental Psychobiology.*

Ditman, T. & Kuperberg, G. R. (2007). The time course of building discourse coherence in schizophrenia: an ERP investigation. *Psychophysiology 44*, 991-1001.

Ditman, T., & Kuperberg, G. R. (2010). Building coherence: A framework for exploring the breakdown of links across clause boundaries in schizophrenia. *Journal of Neurolinguistics 23*, 254–269.

Ekman, P., O'Sullivan, M., Friesen, W. V. & Schererk, K. R. (1991). Face, voice and body in detecting deceit. *Journal of Nonverbal Behavior, 15*: 125-135.

Elvevåg, B., Helsen, K., De Hert, M., Sweers, K., Storms, G. (2011). Metaphor interpretation and use: A window into semantics in schizophrenia. *Schizophrenia Research, Vol. 133, Issues 1-3: 205–211.*

Faludi G., Mirnics K., (2011). Synaptic changes in the brain of subjects with schizophrenia. *International Journal of Developmental Neuroscience, May ; 29(3):* 305–309.

Filik, R. (2008). Contextual override of pragmatic anomalies: Evidence from eye movements. *Cognition, 106*, 1038-1046.

Filik, R, Leuthold, H., Wallington, K., Page, J. (2014). Testing Theories of Irony Processing Using Eye-Tracking and ERPs. *Journal of Experimental Psychology. Learning, memory, and cognition. 40. 10.1037.*

Filik, R., Moxey, L. M. (2010). The On-line Processing of Written Irony. *Cognition, 116, issue 3*: 421-436.

Finckh, J., (1906). Zur Frage der Intelligenzprüfung. *Zentralbl Nervenheilkd. Psychiatr, 29*, 945–957.

First, Michael B., Spitzer, Robert L, Gibbon Miriam, and Williams, Janet B.W (2002). Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition With Psychotic Screen (SCID-I/P W/ PSY SCREEN) New York: Biometrics Research, New York State Psychiatric Institute.

Frith, C. D. (1992). The Cognitive Neuropsychology of Schizophrenia. Hove, UK, Lawrence Erlbaum Associates.

Frisson, S., & Pickering, M. J. (1999). The processing of metonymy: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25(6)*: 1366-1383.

Frisson, S. & McElree, B., (2008). Complement coercion is not modulated by competition: Evidence from eye movements. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 34(1)*, 1-11.

Fuller, R.; Nopoulos, P.; Arndt, S.; O'Leary, D.; Ho, B. C.; & Andreasen, N. C. (2002). Longitudinal assessment of premorbid cognitive functioning in patients with schizophrenia through examination of standardized scholastic test performance. *The American Journal of Psychiatry, 159*, 1183-9.

Garey, L. (2010). When cortical development goes wrong: schizophrenia as a neurodevelopmental disease of microcircuits

Gernsbacher, M. A., Tallent, K. A., & Bolliger, C. M. (1999). Disordered discourse in schizophrenia described by the structure building framework. *Discourse Studies, 1(3)*, 355-372.

Gibbs, R. W. (1986). On the psycholinguistics of sarcasm. *Journal of Experimental Psychology: General, 115(1)*, 3-15.

Gibbs, R. W. (1994). The poetics of mind. Cambridge University Press, Cambridge.

Gibbs, R. W. (2002). A new look at literal meaning in understanding what is said and implicated. *Journal of Pragmatics, Vol. 34, Issue 4*: 457-486.

Gibbs, R. W., O'Brian, J., & Doolittle, S. (1995). Inferring meanings that are not intended: Speakers' intentions and irony comprehension. *Discourse Processes, 20*, 187-203.

Giora, R. (1995). On irony and negation. *Discourse Processes, 19:* 239–264.

Giora, R. (1997). Understanding figurative and literal language: The graded salience hypothesis. *Cognitive Linguistics, 8*, 183-206.

Giora, R. (2003). *On Our Mind: Salience, Context and Figurative Language*. Oxford University Press.

Giora, R., & Fein, O. (1999). Irony: Context and salience, *Metaphor and Symbol 14*, 241-257.

Glantz, L. A., Lewis, D. A. (2000). Decreased Dendritic Spine Density on Prefrontal Cortical Pyramidal Neurons in Schizophrenia. *Archives of General Psychiatry, 57(1):*65-73.

Glucksberg, S., Gildea, P., Bookin, H. B. (1982). On Understanding Nonliteral Speech: Can People Ignore Metaphors? *Journal of Verbal Learning and Verbal Behavior*, *Volume 21, Issue* 1: 85-98.

Glucksberg, S., Keysar, B., (1990). Understanding metaphorical comparisons: Beyond similarity. *Psychological Review, Vol 97(1):* 3-18.

Goldman-Rakic, P. S., Selemon, L. D. (1997). Functional and Anatomical Aspects of Prefrontal

Pathology in Schizophrenia. *Schizophrenia Bulletin, 23(3)*:437-458.

Goeleven, E., De Raedt, R., Leyman, L. & Verschuere, B. (2008). The Karolinska Directed Emotional Faces: A Validation Study. *Cognition and Emotion, 22*: 1094-1118.

Granpeesheh, D., Tarbox, J., Najdowski, A. & Kornack, J. (2014). Evidence-Based Treatment for Children with Autism - The CARD Model, 1st Edition, Academic Press.

Grant, D. A., & Berg, E. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology, 38(4)*: 404-411.

Green, M. F. (1996). What are the functional consequences of neurocognitive deficits in schizophrenia? *The American Journal of Psychiatry*; *Vol. 153*, *Iss. 3*: 321-30.

Green, M. F., Kern, R. S, Braff, D. L., Mintz J. (2000). Neurocognitive deficits and functional outcome in schizophrenia: are we measuring the "right stuff"? *Schizophrenia Bulletin, 26(1):*119-36.

Grice, H. P. (1975) 'Logic and conversation'. In P. Cole and J. Morgan (Eds.) *Studies in Syntax and Semantics III: Speech Acts* (pp. 183-198), New York: Academic Press.

Happé, F. G. E. (1993). Communicative competence and theory of mind in autism: A test of relevance theory. *Cognition, Vol. 48, Issue 2:* 101-119.

Happé, F. G. E. (1995) Understanding Minds and Metaphors: Insights from the Study of Figurative Language in Autism, *Metaphor and Symbolic Activity, 10:4,* 275-295.

Herold, R., Tényl, T., Lénárd, K. & Trixler, M. (2002). Theory of mind deficit in people with schizophrenia during remission. *Psychological Medicine, Vol. 32, Issue 6:* 1125-1129.

Henry, J. D., Bailey, P. E., & Rendell, P. G. (2008). Empathy, social functioning and schizotypy. *Psychiatry Research, 160(1)*, 15–22.

Hoff, A. L., Sakuma, M., Wieneke, M., Horon, R., Kushner, M., & De Lisi, L. E. (1999). Longitudinal neuropsychological follow-up study of patients with first-episode schizophrenia. *The American Journal of Psychiatry 156*, 1336-41.

Hofer, A., Rettenbacher, M. A., Widschwendter, C. G., Kemmler, G., Hummer, M., Fleischhacker, W. W. (2006). Correlates of subjective and functional outcomes in outpatient clinic attendees with schizophrenia and schizoaffective disorder. *European. Archives of. Psychiatry and Clinical Neuroscience, 256:*246–255.

Iakimova, G., Passerieux, C., Laurent, J.-P., & Hardy-Bayle, M.-C. (2005). ERPs of metaphoric, literal, and incongruous semantic processing in schizophrenia. *Psychophysiology 42,* 4, 380-390.

Iakimova, G., Passerieux, C., & Hardy-Bayle, M.-C. (2006). Interpretation of ambiguous idiomatic statements in schizophrenic and depressive patients. Evidence for common and differential cognitive patterns. *Psychopathology, 39*, 6, 277-285.

Jackendoff, R. (1997). The architecture of language faculty. *Linguistic Inquire Monographs, 28.* The MIT Press.

Johnstone E. C., Ebmeier K. P., Miller P., Owens D. G. C. (2005). Predicting schizophrenia: findings from the Edinburgh High-Risk Study. *The British Journal of Psychiatry*, *Vol. 186, Issue 1:* 18-25.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99(1):* 122-149.

Katz, A. N. & Ferretti, T. R. (2001) Moment-By-Moment Reading of Proverbs in Literal and Nonliteral Contexts, *Metaphor and Symbol, 16:3-4*: 193-221.

Kaakinen, J.K., Olkoniemi, H., Kinnari, T., & Hyönä, J. (2014). Processing of written irony: An eye movement study. *Discourse Processes, 51*, 287–311.

Kaeserman, M.L. (1987). The analysis of dialogues with a schizophrenic patient. In Wodak, R. & Van de Craen, P. (Eds.). *Neurotic and Psychotic Language Behavior* (pp.277-303). Clevedon, Multilingual Matters Ltd.

Kay, S.R., Opler, L.A., Fiszbein, A. (1986) The Positive and Negative Syndrome Scale (PANSS): Rating manual. *Social and Behavioral Sciences Documents 17,* 28–29 (Whole No. 2807).

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. *Journal of Abnormal Psychology 11*, 211-24.

Keysar, B. (1989). On the functional equivalence of literal and metaphorical interpretations in discourse. *Journal of Memory and Language, Vol. 28, Issue 4*: 375-385

Keysar, B. (1997). Unconfounding common ground. *Discourse Processes, 24:* 253–270.

Keysar, B. Lin, S., Barr, D. J. (2003). Limits on theory of mind use in adults. *Cognition*, *89*: 25-41.

Keysar, B., Barr, D. J., Balin, J. A., & Brauner, J. S. (2000). Taking perspective in conversation: The role of mutual knowledge in comprehension. *Psychological Science, 11*: 32–38.

Kiang, M., Kutas, M., Light, G. A., & Braff, D. L. (2008). An event-related brain potential study of direct and indirect semantic priming in schizophrenia. *American Journal of Psychiatry, 165,* 74–81.

Kircher, T., Leube, D., Erb, M., Grodd, W., & Rapp, A. (2007). Neural correlates of metaphor processing in schizophrenia. *Neroimage, 34*, 281-289.

Knapp, M. L., Hall, J. A. & Horgan, T. G. (2014). Nonverbal Communication in Human Interaction. *Wandsworth Cengage Learning*.

Koechlin E., Ody C., Kouneiher F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science, Nov 14;302(5648)*:1181-5.

Kohler, C. G. Walker, J. B., Martin, E. A., Healey, K. M. & Moberg, P. J. (2010). Facial Emotion Perception in Schizophrenia: A Meta-analytic Review. *Schizophrenia Bulletin, 36(5):* 1009-1019.

Krauss, R. M., & Glucksberg, S. (1977). Social and nonsocial speech. *Scientific American, 236*: 100–105.

Kreuz, R. J., & Glucksberg, S. (1989). How to be sarcastic: The echoic reminder theory of verbal irony. *Journal of Experimental Psychology: General, 118(4):* 374-386

Kuperberg, G. (2010a). Language in schizophrenia. Part 1: An introduction. *Language and Linguistics Compass 4/8*, 576-589.

Kuperberg, G. (2010b). Language in schizophrenia. Part 2: What can psycholinguistics bring to the study of schizophrenia…and vice versa? *Language and Linguistics Compass 4/8*, 590-604.

Kuperberg, G., McGuire, P. K., & David, A. (2000). Sensitivity to linguistic anomalies in spoken sentences: a case study approach to understanding thought disorder in schizophrenia. *Psychological Medicine, 30*, 345-357.

Kuperberg, G., & Heckers, S. (2000). Schizophrenia and cognitive function. *Current Opinion in Neurobiology 10*, 205-10.

Kuperberg, G., West, W. C., Goff, D., & Lakshmanan, B. (2008). fMRI reveals neuroanatomical dissociations during semantic integration in schizophrenia. *Biological Psychiatry 64*, 407-18.

Kuperberg, G., Goff, D., McGuire, P. K., & David, A. S. (2006b). Building up linguistic context in schizophrenia: Evidence from self-paced reading. *Neuropsychology, 20*, 442-52.

Kuperberg, G., Kreher, D. A., Ditman, T. (2010). What can Event-related Potentials tell us about language, and perhaps even thought, in schizophrenia? *International Journal of Psychophysiology*, Vol. 75, Issue 2: 66-76.

Kutas, M., Van Peten, C., & Kluender, R. (2006). Psycholinguistics electrified II: 1994-2005. In M. Traxler, & M.A. Gernsbacher (Eds.), *Handbook of Psycholinguistics* (pp. 659-

724). New York: Elsevier.

Larøi, F., Fonteneau, B., Mourad, H., Raballo, A. (2010). Basic Emotion Recognition and Psychopathology in Schizophrenia. *The Journal of Nervous and Mental Disease*, *Vol. 198 - Issue 1:* 79-81.

Langdon, R., & Coltheart, M. (1999). Mentalising, schizotypy, and schizophrenia. *Cognition, 71(1)*, 43–71.

Langdon, R., & Coltheart, M. (2004). Recognition of metaphor and irony in young adults: The impact of schizotypal personality traits. *Psychiatry Research, 125(1)*, 9–20.

Langdon, R., Coltheart, M., Ward, P. B., & Catts, S. V. (2002). Disturbed communication in schizophrenia: The role of poor pragmatics and poor mind-reading. *Psychological Medicine, 32(7)*, 1273–1284.

Langdon, R., Davies, M., Coltheart, M. (2002). Understanding Minds and Understanding Communicated Meanings in Schizophrenia. *Mind and Language,* Wiley *Online Library,* https://doi.org/10.1111/1468-0017.00189.

Lascarides, A., & Copestake, A. (1998). Pragmatics and word meaning. *Journal of Linguistics, 34(2):* 387-414.

Lee, J., & Park, S. (2005). Working memory impairments in schizophrenia: A meta-analysis. *Journal of Abnormal Psychology 114*, 599-611.

Lee, S. B., Koo, S. J., Song, Y., Y., Lee, M. K., Jeong, Y. J., Kwon, C., Park, K. R., Park, J. Y. (2014). Theory of Mind as a Mediator of Reasoning and Facial Emotion Recognition: Findings from 200 Healthy People. *Psychiatry Investigation, 11(2):* 105–111.

Leech, G. (1981). Semantics: *The Study of Meaning*. Harmondsworth, U.K., Penguin.

Lesh, T. A., Niendam, T. A., Minzenberg, M. J. & Carte, C. S. (2010). Cognitive Control Deficits in Schizophrenia: Mechanisms and Meaning. *Neuropsychopharmacology 36:* 316–338.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska Directed Emotional Faces - KDEF, CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, ISBN 91-630-7164-9.

Lysaker, P. H., Daws, L. W., & Hunter, N. (2004) Neurocognitive, Social and Clinical Correlates of Two Domains of Hopelessness in Schizophrenia. *Schizophrenia Research, 70:* 277-285.

Marslen-Wilson, W. D., Brown, C., & Tyler, L. K. (1988). Lexical Representations in Language Comprehension. *Language and Cognitive Processes 3*, 1-17.

Mashal, N., Vishne, T., Laor N., Titone, D. (2013). Enhanced Left Frontal Involvement during Novel Metaphor Comprehension in Schizophrenia: Evidence from functional neuroimaging. *Brain and Language, Volume 124, Issue 1:* Pages 66-74.

McElree, B., Frisson, S., & Pickering, M. (2006). Deferred Interpretations: Why starting Dickens is taxing but reading Dickens isn't. *Cognitive Science 30(1)*, 181-192.

McKay, T., & Nelson, M. (2014). Propositional attitude reports (Spring 2014 Edition). In E. N. Zalta (Ed.), The Stanford encyclopedia of philosophy. Retrieved from http://www.plato.stanford.edu/archives/spr2014/entries/prop-attitude-reports/Google Scholar.

Mitchell, R. L. C., & Crow, T. J. (2005). Right hemisphere language functions and schizophrenia: The forgotten hemisphere? *Brain, 128*: 963–978.

Mo, S., Su, Y., Chan, R. C., and Liu, J. (2008). Comprehension of metaphor and irony in schizophrenia during remission: the role of theory of mind and IQ. *Psychiatry Research 157*: 21–29. doi: 10.1016/j.psychres.2006.04.002.

Moncrieff, J., (2009). A Critique of the Dopamine Hypothesis of Schizophrenia and Psychosis. *Harvard Review of Psychiatry*, Vol. 17, 2009 - Issue 3: 214-225.

Monetta, L., & Pell, M. D. (2007). Effects of verbal working memory deficits on metaphor comprehension in patients with Parkinson's disease. *Brain & Language 101*, 80-89.

Moritz, S., Mersmann, K., Kloss, M., Jacobsen, D., Wilke, U., Andresen, B., Naber, D., & Pawlik, K. (2001). 'Hyperpriming' in thought-disordered schizophrenic patients. *Psychological Medicine, 31*, 221-9.

Mossaheb, N., Aschauer, H. N., Stoettner, S., Schmoeger, M., Pils, N., Raab, M., et al. (2014). Comprehension of metaphors in patients with schizophrenia-spectrum disorders. *Comprehensive Psychiatry 55:* 928–937.

Mueser K. T., Blanchard J. J., Bellack A.S. (1995). Memory and social skill in schizophrenia: the role of gender. Psychiatry Research, Volume 57, Issue 2, 141–153.

Mueser K. T., Doonan R., Penn D. L., Blanchard J. J., Bellack A.S., Nishith P., DeLeon J. (1996). Emotion recognition and social competence in chronic schizophrenia. Journal of Abnormal Psychology., May;105(2):271-5.

Nielsen, R. E., Lindström, E., Telleus, G. K., Levander, S. (2014). Is the PANSS Cognitive Scale Measuring Cognition. *Nordic Journal of Psychiatry*, *Vol. 68, n. 8*: 573-578.

Nickerson, R. S. (1999). How we know, and sometimes misjudge, what others know: Imputing one's own knowledge to others. *Psychological Bulletin, 125:* 737–759.

Novaes, M. (2002). Communication paradoxes in psychosis: A question for cognitive approaches to pragmatics. *ABRALIN Review, 1(1)*, 171-184.

Nunberg, G. (2004). The Pragmatics of Deferred Interpretation. In: Blackwell Encyclopedia of Pragmatics, Laurence Horn and Gregory Ward, eds., Blackwell.

Ortony, A. (1979). Beyond literal similarity. *Psychological Review, 86(3)*: 161-180.

Ott, S. L., Allen, J., & Erlenmeyer-Kimling, L. (2001). The New York high-risk project: Observations on the rating of early manifestations of schizophrenia. *American Journal of Medical Genetics, 105*, 25-7.

Paczynski, Jackendoff & Kuperberg (2014). When events change their nature: the neurocognitive mechanisms underlying aspectual coercion. *Journal of Cognitive Neuroscience, 26(9)*, 1905-17.

Peleg, O. Giora, R. & Fein, O. (2001) Salience and Context Effects: Two Are Better Than One, *Metaphor and Symbol, 16:3*-4: 173-192.

Pesciarelli et al. (2014). Is the comprehension of idiomatic sentences indeed impaired in paranoid Schizophrenia? A window into semantic processing deficits. *Frontiers in Human Neuroscience, October.*

Pexman, M., Ferretti, T. R. & Katz, A., N. (2010) Discourse Factors That Influence Online Reading of Metaphor and Irony, Discourse Processes, 29:3, 201-222.

Pickering, M. J, Frisson, S. (2001). Processing ambiguous verbs: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, Vol. 27(2)*: 556-573.

Pickering, M. J., McElree, B., & Traxler, M. J. (2005). The difficulty of coercion: A response to de Almeida. *Brain & Language, 93*, 1–9.

Pickering, M. J., McElree, B., Frisson, S., Chin, L., & Traxler, M. (2006). Aspectual coercion and underspecification. *Discourse Processes, 42*, 131–155.

Pickpup, G. J. (2006). Theory of mind and its relation to schizotypy. *Cognitive Neuropsychiatry, 11(2)*, 177–192.

Pickup, G. J., Frith, C. D. (2001). Theory of mind impairments in schizophrenia: symptomatology, severity and specificity. *Psychological Medicine, 31(2):*207-20.

Piñango, M. M., Zurif, E. B., & Jackendoff, R. (1999). Real-time processing implications of enriched composition and the syntax-semantics interface. *Journal of Psycholinguistic Research, 28*, 395–414.

Piñango, M. M., Winnick, A., Ullah, R., & Zurif, E. B. (2006). Time-course of semantic composition: The case of aspectual coercion. *Journal of Psycholinguistic Research, 35*, 233–244.

Pylkkănen, L., Martin, A., McElree, B. & Smart, A. (2008). The anterior midline field: coercion or decision making? *Brain and Language, Vol. 108, Issue 3*: 184-190.

Pylkkănen, L., McElree, B. (2007). An MEG Study of Silent Meaning. *Journal of Cognitive Neuroscience, Vol. 19, Issue 11:* 1905-1921.

Pustejovsky, J. Bouillon, P. (1995). Aspectual Coercion and Logical Polysemy, *Journal of Semantics, Vol. 12, Issue 2, 1*: 133–162

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for

Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rapp, A. M., Mutscher, D. E., Wild, B., Erb, M., Lengsfeld, I., Saur, R., & Grodd, W. (2010). Neural correlates of irony comprehension: The role of schizotypal personality traits. *Bra in & Language, 113*, 1-12.

Reich, J. H. (1981). Proverbs and the modern mental status exam. *Comprehensive Psychiatry 22*, 528.

Reichenberg, A., Harvey, P. D., Bowie, C. R., Mojtabai, R., Rabinowitz, J., Heaton, R., & Bromet, E. (2009). Neuropsychological function and dysfunction in schizophrenia and psychotic affective disorders. *Schizophrenia Bulletin, 35(5)*, 1022–1029.

Reynolds, G. P. (1988) Postmortem neurochemistry of schizophrenia. *Psychological Medicine, 18*: 793–797.

Ripke, S., Neale, B.M., Corvin, A., Walters, J.T.R., Farh, K.H., Holman, P.A. and Schizophrenia Working Group of the Psychiatric Genomics Consortium. Biological insights from 108 schizophrenia-associated genetic loci. *Nature. 2014;511*:421–427.

Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1994). *The test of everyday attention.* Pearson, Cambridge.

Rubio-Fernández, P., Jara-Ettinger, J.& Gibsona, E. (2017). Can processing demands explain toddlers' performance in false-belief tasks? *Proceedings of the National Academy of Sciences U S A.*, *114(19)*: E3750.

Samson D., Apperly I. A, Kathirgamanathan U., Humphreys, G.W. (2005). Seeing it my way: a case of a selective deficit in inhibiting self-perspective. Brain., 128(Pt 5):1102-11.

Samson, D., Apperly, I. A., Braithwhaite, J. J., Andrews, B. J., & Bodley Scott, S. E. (2010). Seeing it their way: Evidence for rapid and involuntary computation of what other people see. *Journal of Experimental Psychology: Human Perception and Performance, 36 (5),* 1255-1266.

Santiesteban I., Shah P., White S., Bird G., Heyes C. (2015). Mentalizing or submentalizing in a communication task? Evidence from autism and a camera control. *Psychonomic Bulletin & Review, 22(3)*: 844-9.

Saussure, F. (1969). *Cours de linguistique générale*. Paris, Payot.

Schreber, D. P. ([1955] 2000). *Memoirs of my nervous illness*. New York, New York Review Books.

Schettino, A., Lauro, L. R., Crippa, F., Anselmetti, A., Cavallaro, R., Papagnoa, C. (2010). The Comprehension of Idiomatic Expressions in Schizophrenic Patients. *Neuropsychologia, Vol. 48, Issue 4:* 1032-1040.

Schultz, P. W., Searleman, A. (2002). Rigidity of thought and behavior: 100 years of research. *Genetic, Social and General Psychology Monographs, 128(2):* 165-207.

Searle, J. R. (1979). *Expression and meaning*, Cambridge: Cambridge University Press.

Searle, J. (1983). *Intentionality: An essay in the philosophy of mind*, Cambridge: Cambridge University Press.

Sekar, A., Bialas, A., de Rivera, H. Davis, A., Hammond, T. et al. (2016). Schizophrenia risk from complex variation of complement component 4. *Nature, Volume 530*: 177–183.

Sela T., Lavidor M., Mitchell R. (2015). A possible contributory mechanism for impaired idiom perception in schizophrenia. *Psychiatry Research, Volume 229, Issues 1-2:* 1–11.

Simon, A. E., Cattapan-Ludewig, K., Zmilacher, S., Arbach, D., Gruber, K., Dvorsky D. N., Roth, B., Isler, E., Zimmer, A., & Umbricht, D. (2007). Cognitive functioning in the schizophrenia prodrome. *Schizophrenia Bulletin, 33*, 761-71.

Sitnikova, T., Perrone, C., Goff, D., & Kuperberg, G. (2010). Neurocognitive mechanisms of conceptual processing in healthy adults and patients with schizophrenia. *International Journal of Psychophysiology 75*, 86-99.

Sitnikova, T., Salisbury, D. F., Kuperberg, G., & Holcomb, P. I. (2002). Eletrophysiological insights into language processing in schizophrenia. *Psychophysiology 39*, 851-60.

Sodian, B., Thoermer, C., & Metz, U. (2007). Level-1 visual perspective taking in 14-month-old infants. *Developmental Science, 10*: 199– 204.

Spitzer, M. (1993). The psychopathology, neuropsychology and neurobiology of associative and working memory in schizophrenia. *European Archives of Psychiatry and Clinical Neuroscience 243*, 57-70.

Spotorno, N., Koun, E., Prado, J., Van Der Henst, J. B., & Noveck, I. A. (2012). Neural evidence that utterance-processing entails mentalizing: The case of irony. *NeuroImage, 63(1)*:25–39.

Spotorno, N., Cheylus, A., Van Der Henst, J-B., Noveck, I. (2013). What's behind a P600? Integration operations during irony processing. *PLOS*| *One,* https://doi.org/10.1371/journal.pone.0066839.

Spotorno, N., & Noveck, I. A. (2014). When is irony effortful? *Journal of Experimental Psychology: General, 143(4)*: 1649-1665.

Stanghellini, G. (2008). Schizophrenic delusions, embodiment and the background. *Philosophy, Psychiatry and Psychology, 15 (4)*, 311-314.

Staub, A., Grant, M., Clifton, C., Jr., & Rayner, K. (2009). Phonological typicality does not influence fixation durations in normal reading. *Journal of Experimental Psychology:*

Learning, Memory, and Cognition, 35, 806–814.

Sucksmith, E., Allison, C, Baron-Cohen, S., Chakrabarti, B., & Hoekstra, R. A. (2013). Empathy and emotion recognition in people with autism, first-degree relatives, and controls. *Neuropsychologia, 51(1)*, 98–105.

Tartter, V. C., Gomes, H., Dubrovsky, B., Molholm, S., & Stewart, R. V. (2002). Novel metaphors appear anomalous at least momentarily: Evidence from N400. *Brain & Language, 80(3)*, 488-509.

Traxler, J, McElree, B., Williams, R. S., Pickering, M. J. (2005). Context effects in coercion: Evidence from eye movements. *Journal of Memory and Language*, *Vol. 53, Issue 1:* 1-25.

Tavano et al. (2008). Specific linguistic and pragmatic deficits in Italian patients with schizophrenia. *Schizophrenia Research, Volume 102, Issues 1-3:* 53–62.

Thoma, P., & Daum, I. (2006). Neurocognitive mechanisms of figurative language processing: Evidence from clinical dysfunctions. *Neuroscience and Biobehavioral Reviews, 30*, 1182-1205.

Titone, D., Levy, D., & Holzman, P. S. (2000). Contextual insensitivity in schizophrenic language processing: Evidence from lexical ambiguity. *Journal of Abnormal Psychology, 109(4)*, 761-767.

Traxler, M. J., McElree, B., Williams, R. S., Pickering, R. S. (2005). Context effects in coercion: Evidence from eye-movements. *Journal of Memory and Language, 53*, 1–25.

Traxler M. J., Pickering, M. J., McElree B. (2002). Coercion in sentence processing: Evidence from eye-movements and self-paced reading. *Journal of Memory and Language, 47(4)*, 530–547.

Ţurcan, A., & Filik, R. (2016). An eye-tracking investigation of written sarcasm comprehension: The roles of familiarity and context. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 42(12)*, 1867–1893.

Turner, N. E., & Katz, A. N. (1997). The availability of conventional and of literal meaning during the comprehension of proverbs. *Pragmatics and Cognition, 5(2),* 199-233.

Weickert, T. W, Goldberg, T. E., Gold, J. M., Bigelow, L. B., Egan, M. F., Weinberger, D. R. (2000). Cognitive Impairments in Patients with Schizophrenia Displaying Preserved and Compromised Intellect. *Archives of General Psychiatry, 57(9):* 907–913.

Weisbrod, M. S., Maier, S., Harig, S., Himmelsbach, U., & Spitzer, M. (1998). Lateralised semantic and indirect semantic priming effects in people with schizophrenia. *The British Journal of Psychiatry, 156*, 204-10.

Wiederholt, J. L., & Blalock, G. (2000). Gray Silent Reading Tests. Pro-ed, Austin.

Wood, S. J., Tarnawski, A. U., Proffitt, T. M., Brewer, W. J., Savage, G. R., Anderson, V., McGorry, P. D., Velakoulis, D., & Pantelis, C. (2007). Fractionation of verbal memory impairment in schizophrenia and schizophreniform psychosis. *The Australian and New Zealand Journal of Psychiatry, 41*, 732-9.

Wróbel, J. (1987). The language of schizophrenics as a reflection of meanings concealed by culture and the individual. In R. Wodak, & P. Van de Craen (Eds.). *Neurotic and Psychotic Language Behavior* (pp. 346-362). Clevedon, Multilingual Matters Ltd.

Wu, Y. & Larrabee, H., June, H. & Putman, P. (2006). Caring Behaviors Inventory: a reduction of the 42-item instrument. *Nursing research. 55:* 18-25.

Zea, M. C., Asner-Self, K. K., Birman, D., & Buki, L. P. (2003). The Abbreviated Multidimensional Acculturation Scale: Empirical validation with two Latino/Latina samples. *Cultural Diversity & Ethnic Minority Psychology, 9*: 107-126.

APPENDIX A

The Control and Flexibility Task

The Control and Flexibility task was created by the experimenter to test participants' ability to inhibit activation of non-relevant thoughts and memories and focus on the purpose of the task. The purpose of the task was to find sentences on the right column that would match corresponding abbreviations on the left column and then connect them with a line. If there were not a match for a sentence among the abbreviations in the left column, then participants would have to write "No match" either beside the sentence or beside the abbreviation.

Participants had two minutes to complete the task. About 6 abbreviations out of a total of 14 could be read as separate words, like "L.O.V.E.", "L.O.N.D.O.N", "P.E.A.C.E", "P.A.P.E.R.". Participants were supposed to inhibit activations connected to these words and see them purely as abbreviations representing sentences on the right in order to complete the task.

Participants were given ample explanation about how to do the task before doing it.

Section 1: The Cognitive Control Task

Choose a sentence in the right that best matches the abbreviations on the left and connect them with a line. If you find that there is no match, write "No match" beside the abbreviations that have no correspondent sentences for them. Make as many connections as you can. You will be informed when time is out.

Example: I.C.H.Y. ________________________________ I CAN'T HEAR YOU

L.O.V.E	Two wrongs don't make a right.
D.A.Y.A.N.D.N.I.T.	Would you fill out this form, please?
A.E.Y.W.L.T.O	I hope you and your wife have a nice trip.
P.E.A.C.E.	I was about to leave the restaurant when my friends arrived.
L.O.N.D.O.N.	I don't know how to use this.
T.W.D.M.A.R.	I'm sorry we're sold out.
I.D.K.H.T.U.T.	Diana and Youssef are not distant now, I think.
D.O.G.	I am not going to the party tonight.
I.W.A.T.L.T.R.W.M.F.A.	Laura owes nothing, David Orson noted.
P.O.S.T.	You're not comfortable, I guess.
I.S.W.S.O.	The pen is mightier than the sword.
P.A.P.E.R.	Linda Orwell visited Emma.

M.I.S.T.T.M.P.	Don’t overreact, Gary.
I.H.Y.A.Y.W.H.A.N.T.	Phil and Phoebe earn riches.

APPENDIX B

Participants from both groups made more mistakes when appreciating surprise than when appreciating sadness, $t(55) = 4.497$, $p < .001$, anger, $t(55) = 3.772$, $p < .001$, fear, $t(55) = 9.014$, $p < .001$, happiness, $t(55) = 12.314$, $p < .001$ and disgust, $t(55) = 8.301$, $p < .001$. They also made more mistakes when appreciating sadness than when appreciating fear, $t(55) = 3.386$, $p < .001$, happiness, $t(55) = 6.588$, $p < .001$ and disgust, $t(55) = 3.641$, $p = .001$.

Participants from both groups made more mistakes when appreciating anger than when appreciating fear, $t(55) = 5.037$, $p < .001$, happiness, $t(55) = 9.040$, $p < .001$ and disgust, $t(55) = 5.017$, $p < .001$.They also made more mistakes when appreciating fear than when appreciating happiness, $t(55) = 4.172$, $p < .001$ and they made more mistakes when appreciating neutrality than when appreciating sadness, $t(55) = 3.506$, $p = .001$, anger, $t(55) = 2.969$, $p < .005$, happiness, $t(55) = 9.070$, $p < .001$, fear, $t(55) = 6.462$, $p < .001$ and disgust, $t(55) = 7.032$, $p < .001$.

Emotions that caused participants to make more mistakes were surprise, neutrality, sadness and fear.

APPENDIX C

PLEASE READ THE INSTRUCTIONS CAREFULLY!!!

You will see 40 sentences fragments. For each fragment, you will have to answer 2 questions. These questions are:

1. Is the sentence ironic? Answer with Y for YES or N for NO.
   Irony is about an expression being used to signify the opposite of what the person is saying, giving it a humorous or emphatic effect. For example, imagine it is bitter cold and grey outside and someone says: “Beautiful weather, isn’t it?” The sentence “Beautiful weather, isn’t it?” is used in an ironic way because bitter cold and grey weather is usually not considered beautiful. However, it the neighbor had said to the other, “Awful weather, isn’t it?”, this would not have been ironic;

2. How easy is it to understand the irony in the fragment on a scale from 1 to 7? If it was very hard to understand the irony in the fragment, write down 1, if it was very easy, write down 7. Use the rest of the scale to indicate gradations (e.g. 4 means neither hard not easy). If you indicated that the sentence was literal, then you want to write a 1 in this column.

3. If you wrote down that the underlined sentence is ironic, indicate on a scale from 1 to 7 how familiar you are with the ironic expression with 1 meaning not at all familiar and 7 meaning very familiar (use the scale to indicate gradations). If you wrote down that the expression was not used ironically, leave this column open!

Item	Condition	Ironic Fragment	Average – Ironic? 1 Yes/0 No
2	1	At dinner John was bragging about how he beat all his competitors in the swimming championship at school. Later, he admitted that apart from him all the other competitors were at least five years younger. His sister Laura said, “What an accomplishment!” and she raised her glass.	0.75
3	1	Fifty people were standing in a queue to get tickets for the show when suddenly a woman jumped in front of them and said it was now her turn to be served. Someone from the queue shouted “Very smart!” and called security instantly.	0.91
4	1	The girl was trying to open the house door, when suddenly she felt two cold hands around her neck. She screamed and when she turned back she saw that it was her brother. He was laughing. She said “Very funny!” and then slammed the door in his face.	0.91
5	1	There are five people in a waiting room. Suddenly, a man lights a cigarette. A woman sitting beside him gets annoyed. She says, “How incredibly polite” and the man stands up, but continues to smoke.	1
6	1	Jessie’s boss told her, “I can’t pay you for the next month, but when I get that big order in, I’ll pay you half your salary.” She said to her boss, “That’s wonderful news!” and immediately called her friend.	0.09
7	1	Linda’s boss said to her, “Now that James and Margaret resigned, you’ll have to do their jobs as well and will need to come in over the weekends and stay longer every day.” Linda replied, “I couldn’t be more thrilled!” and returned to her desk.	0.82
8	1	A man is carrying his drunken son back to his bedroom, when suddenly the boy throws up on the father’s new expensive Ralph Lauren shirt. The father says, “Oh, great!” and tries to get his son to sit down.	1
9	1	A woman received a phone call from the police. They said that her drunken son had crashed a neighbour’s car that had not been lent to him and was now in jail. When they told her that the bail amounted to £10,000, she said, “That’s super news!” and hung up.	0.91
10	1	Liam had heard that putting your savings in shares could be very profitable. He bought some stocks in a small company, but one month later the company went bust and he lost all his money. He said, “That’s what I call a worthwhile investment” and he poured himself a drink.	1
11	1	Karen and Jean are playing chess in a park. They have just started their game. Each one develops their own strategy. After only six moves, Karen manages to beat Jean. Jean says to her: “Clearly, we’re the same level” and gives her a wink.	0.95
12	1	After queuing for fifteen minutes outside a theatre in Covent Garden, the couple realises that there are no further taxis available to hire and that they will have to walk in the bitter cold for at least an hour. The wife says, “Isn’t that wonderful?” and the husband just nods his head.	1

13	1	The lady lent a rare and expensive book to her neighbour three months ago. She really wants it back, but he can't find it anywhere. He tells the lady, "I think I lost your book. I hope you won't be disappointed." The lady replies, "Oh, no, not disappointed at all" and she gives him a grimace.	0.91
14	1	A lady was telling her friend that a guest in a modern art auction at Sotheby's offered £200 pounds for a painting by Picasso. The friend exclaimed: "What a spectacular offer!" and they giggled.	0.86
15	1	A man was smoking in the restaurant lavatory. When a customer went to that same lavatory, he could smell the cigarette smoke. On his way out, he said to the man who was smoking: "The air in here is very good indeed!" and he left.	0.95
16	1	The opera was having its world premiere, but the conception was mistaken and the music was poor. Lots of people didn't go back to their seats after the first interval. The producer said to the director: "What a superb premiere!" and checked Facebook on his phone to see if people had already posted any comments.	0.82
17	1	While at dinner Brett talks to his colleague about his new foundation to combat dementia. He tells him that he wants to raise at least £100,000. Several months later, they meet again and Brett tells his colleague that they only raised £5,000. The colleague says, "Well, it seems the campaign was a real success" and he ordered another coffee.	0.91
18	1	The girls went to the cinema to see a horror movie that was supposed to be really scary, but the movie was nothing but trivial. At the end of the show, one said to the other: "Oh that was really creepy! How about a drink?" and they went to a pub.	0.91
19	1	Two singers sang together in the same musical. On the night of the last performance they met at the theatre. During the performance they often sang off key. After the show, one said to the other, "Today we gave a terrific performance!" and they started packing to empty their dressing rooms.	0.09
20	1	Four friends are gambling in a casino. In the middle of the night one of them said: "I'll bet my sports car to get my credit back". They go outside to have a look at the car and they realise it's just a Fiat Panda. One of the friends says: "Nice sports car" and they go back to the casino.	0.95
21	1	Amelia and three friends had gone to London for the day. In the evening, she called home to ask her Dad to pick her up in Milton Keynes. She had taken the last train but forgot to check whether she would make the connection. Her father said, "You planned that very well" and then jumped in the car.	1
22	1	Leonard offers to show his new co-worker Karl around town. However, it quickly begins to rain heavily and they are forced to stay at a café without seeing any of the city. Karl tells Leonard, "What a fantastic city!" and they plan to meet again the following day weather permitting.	0.95
23	1	Oliver has gained weight and he decides to go see his doctor. The doctor puts him on a diet. One month after starting the diet, he hasn't lost any weight at all. Oliver goes to see his doctor again and he says: "This diet really works!" and he makes a new appointment for the following month.	0.89

24	1	While at a conference abroad, Peter runs into his colleague Tom. Tom asks him where the university cafeteria is. Peter offers to accompany him and Tom accepts. After looking for over an hour, they finally arrive at the cafeteria. Tom says, “Luckily we found this quickly” and they buy a sandwich.		0.91
25	1	At the party the hostess realised that one of her female guests had gained a lot of weight and was dressed in a track suit. When the guest approached her, the hostess said, “And you, my dear, elegant as ever!” and she looks her all over.		0.91
26	1	Gemma and Steve have the same class this morning. They settle in and listen to the professor. The two students find the lecture uninteresting and tiresome. At the end, Gemma says to Steve, “The professor was captivating today” and they go out for a coffee.		1
27	1	Josie is ill and asks her roommate to prepare her some herbal tea. Josie must stay in bed and rest all day. After drinking the tea, Josie feels even worse and ends up vomiting. Her roommate says, “This tea has really shown its effectiveness” and they decide to turn the TV on.		0.91
29	1	Because he had to work, Brett came home late for dinner. His daughter had already eaten the whole cake that was for dessert, leaving him with just a few crumbs. Brett said: “Thanks for leaving me such a big piece!” and went to wash his hands.		1
30	1	The lecturer was marking assignments. One of these was absolutely awful, showing hardly any understanding of the topic and full of grammatical errors. The lecturer got a pen and wrote, “Great work!” at the bottom of the page.		0.95
31	1	Tom was building an addition to his house. His younger brother was supposed to help, but he didn’t show up. At the end of a long day, when Tom’s brother finally appeared, Tom said, “Thanks for your help” and he put his tools back in the case.		1
32	1	The boy was playing football in the rain and the field was very muddy. When the game was over, he came back home. His clothes were terribly dirty. His mother said, “Thank you for keeping your clothes so clean!” and then she put the clothes in the washing basket.		1
34	1	A widower had bought an enormous two-story flat and she decorated it with marble columns all over. The first time she received guests at her property, one of them said, “How are you enjoying life in this cosy little flat?” and the lady replied, “I’m very happy here indeed”.		0.73
35	1	The book Sophia had been gifted was long and boring. The person who had given it to her asked, “Isn’t that a great novel?” Sophia replied, “An absolute treat” and ordered some wine for both of them.		0.86
36	1	The family TV was many years old and had a crappy image. A friend of their son’s commented, “What a grand TV you have there!” and the son asked his parents to buy a new one immediately.		1
38	1	Michael and Jim go fishing together once a year in a lake. As usual, they talk while waiting for the fish to bite. At the end of the day, neither of them managed to catch a single fish. As they were leaving, Michael told Jim: “Good fishing today” and they returned home.		0.93

39	1	The little chiwawa was barking menacingly at the visitors. One of them said, “I’m scared of that enormous beast” and then its owner decided to give it a treat.	1
40	1	Helen and Gerald were at an art auction. Gerald explained to Helen the value of the ancient Greek sculptures presented. Helen was very interested and listened to him carefully. A Greek sculpture of the Classic period was presented, but no one bid on it. Helen said to Gerald: “The competition was stiff for that sculpture” and started walking outside.	0.82
		Ironic fragments means	0.88

Irony Eye-tracking stimuli.

In the first version (a) of each item the fragment is used ironically. In the second version (b) it is used literally. In the third version (c) a neutral expression was used.

1

a Fifty people were standing in a queue to get tickets for the show when suddenly a woman jumped in front of them and said it was now her turn to be served. Someone from the queue shouted “Very smart!” and called security instantly.

b Fifty people were standing in a queue to get tickets for the show when suddenly a woman had the idea of pre-reserving the tickets on the event’s website via mobile phone. Someone from the queue shouted “Very smart!” and called his mate to do the same.

c Fifty people were standing in a queue to get tickets for the show when suddenly a woman jumped in front of them and said it was now her turn to be served. Someone from the queue shouted “I’m not feeling well” and called security instantly.

2

a The girl was trying to open the house door, when suddenly she felt two cold hands around her neck. She screamed and when she turned back she saw that it was her brother. He was laughing. She said “Very funny!” and then slammed the door in his face.

b The girl was trying to open the house door, when suddenly she saw her brother slip on the snow and kick somebody else’s back unintentionally. She started laughing loudly. She said “Very funny!” and then went over to help him.

c The girl was trying to open the house door, when suddenly she felt two cold hands around her neck. She screamed and when she turned back she saw that it was her brother. He was laughing. She said “You scared me!” and then slammed the door in his face.

3

a There are five people in a waiting room. Suddenly, a man lights a cigarette. A woman sitting beside him gets annoyed. She says, “How incredibly polite” and the man stands up, but continues to smoke.

b There are five people in a waiting room. Suddenly, a woman goes outside to light a cigarette. A man follows her and lights the cigarette for her. She says, “How incredibly polite” and the man starts a conversation.

c There are five people in a waiting room. Suddenly, a man lights a cigarette. A woman sitting beside him gets annoyed. She says, “Your cigarette smells” and the man stands up, but continues to smoke.

4

a A man is carrying his drunken son back to his bedroom, when suddenly the boy throws up on the father’s new expensive Ralph Lauren shirt. The father says, “Oh, great!” and tries to get his son to sit down.

b The man is carrying his younger son back to his bed. When the little boy was grabbing his pillow, he told is father he had got an A+ in his Math’s test. The father says, “Oh, great!” and tries to get his son to sleep again.
c A man is carrying his drunken son back to his bedroom, when suddenly the boy throws up on the father’s new expensive Ralph Lauren shirt. The father says, “What a mess” and tries to get his son to sit down.

5
a A woman received a phone call from the police. They said that her drunken son had crashed a neighbour’s car that had not been lent to him and was now in jail. When they told her that the bail amounted to £10,000, she said, “That’s super news!” and hung up.
b A woman received a phone call from the queen’s staff. They said that her son would be awarded a medal for his incredible driving abilities in Formula 3 competitions. When they told her that the family could also attend the ceremony, she said, “That’s super news!” and hung up.
c A woman received a phone call from the police. They said that her drunken son had crashed a neighbour’s car that had not been lent to him and was now in jail. When they told her that the bail amounted to £10,000, she said, “That’ a lot of money!” and hung up.

6
a Liam had heard that putting your savings in shares could be very profitable. He bought some stocks in a small company, but one month later the company went bust and he lost all his money. He said, “That’s what I call a worthwhile investment” and he poured himself a drink.
b Liam had heard that putting your savings in shares could be very profitable. He bought some stocks in a small company, and one month later the company was sold and he tripled all his money. He said, “That’s what I call a worthwhile investment” and he poured himself a drink.
c Liam had heard that putting your savings in shares could be very profitable. He bought some stocks in a small company, but one month later the company went bust and he lost all his money. He said, “That’s a lot of money down the drain” and he poured himself a drink.

7
a Karen and Jean are playing chess in a park. They have just started their game. Each one develops their own strategy. After only six moves, Karen manages to beat Jean. Jean says to her: “Clearly, we’re the same level” and gives her a wink.
b Karen and Jean are playing chess in a park. They have just started their game. Each one develops their own strategy. After two hours of play, no one has taken the lead, so Jean says, “Clearly, we’re the same level” and gives her a wink.
c Karen and Jean are playing chess in a park. They have just started their game. Each one develops their own strategy. After only six moves, Karen manages to beat Jean. Jean says to her: “Clearly, I don’t play as well as you” and gives her a wink.

8

a After queuing for fifteen minutes outside a theatre in Covent Garden, the couple realises that there are no further taxis available to hire and that they will have to walk in the bitter cold for at least an hour. The wife says, “Isn’t that wonderful?” and the husband just nods his head.

b After queuing for one minute outside a theatre in Covent Garden, the couple realises that there are lots of taxis available to hire and that they will not have to walk home in the bitter cold. The wife says, “Isn’t that wonderful?” and the husband just nods his head.

c After queuing for fifteen minutes outside a theatre in Covent Garden, the couple realises that there are no further taxis available to hire and that they will have to walk in the bitter cold for at least an hour. The wife says, “It’s good we brought our umbrella” and the husband just nods his head.

9

a The lady lent a rare and expensive book to her neighbour three months ago. She really wants it back, but he can’t find it anywhere. He tells the lady, “I think I lost your book. I hope you won’t be disappointed.” The lady replies, “Oh, no, not disappointed at all” and she gives him a grimace.

b The lady lent a rare and expensive book to her neighbour three months ago. He reads it with interest but finds it rather complicated. He tells the lady, “I think I find the book a bit difficult, I hope you are not disappointed.” The lady replies, “Oh, no, not disappointed at all” and she gives him a smile.

c The lady lent a rare and expensive book to her neighbour three months ago. She really wants it back, but he can’t find it anywhere. He tells the lady, “I think I lost your book. I hope you won’t be disappointed.” The lady replies, “Well, I’m not happy about it” and she gives him a grimace.

10

a A lady was telling her friend that a guest in a modern art auction at Sotheby’s offered £200 pounds for a painting by Picasso. The friend exclaimed: “What a spectacular offer!” and they giggled.

b A lady was telling her friend that a guest in a modern art auction at Sotheby’s offered £20 million pounds for a painting by Picasso. The friend exclaimed: “What a spectacular offer!” and they carried on the conversation.

c A lady was telling her friend that a guest in a modern art auction at Sotheby’s offered £200 pounds for a painting by Picasso. The friend exclaimed: “What a ridiculous offer!” and they giggled.

11

a A man was smoking in the restaurant lavatory. When a customer went to that same lavatory, he could smell the cigarette smoke. On his way out, he said to the man who was smoking: “The air in here is very good indeed!” and he left.

b A man was spraying bathroom essence in the restaurant lavatory. When a customer got to that same lavatory, he could smell the citrus essence. On his way out, he said to the man who was spraying the essence: “The air in here is very good indeed!” and he left.
c A man was smoking in the restaurant lavatory. When a customer went to that same lavatory, he could smell the cigarette smoke. On his way out, he said to the man who was smoking: “I wish you would do that somewhere else” and he left.

12
a The opera was having its world premiere, but the conception was mistaken and the music was poor. Lots of people didn’t go back to their seats after the first interval. The producer said to the director: “What a superb premiere!” and checked Facebook on his phone to see if people had already posted any comments.
b The opera was having its world premiere. The conception was perfectly staged and the music was beautiful. Lots of people didn’t want to leave at the end and were still applauding. Afterwards, the producer said to the director: “What a superb premiere!” and checked Facebook on his phone to see if people had already posted any comments.
c The opera was having its world premiere, but the conception was mistaken and the music was poor. Lots of people didn’t go back to their seats after the first interval. The producer said to the director: “What a horrible premiere!” and checked Facebook on his phone to see if people had already posted any comments.

13
a While at dinner Brett talks to his colleague about his new foundation to combat dementia. He tells him that he wants to raise at least £100,000. Several months later, they meet again and Brett tells his colleague that they only raised £5,000. The colleague says, “Well, it seems the campaign was a real success” and he ordered another coffee.
b While at dinner Brett talks to his colleague about his new foundation to combat dementia. He tells him that he wants to raise at least £100,000. Several months later, they meet again and Brett tells his colleague that they raised over a million. The colleague says, “Well, it seems the campaign was a real success” and he ordered another coffee.
c While at dinner Brett talks to his colleague about his new foundation to combat dementia. He tells him that he wants to raise at least £100,000. Several months later, they meet again and Brett tells his colleague that they only raised £5,000. The colleague says, “Well, it seems that the campaign didn’t go too well” and he ordered another coffee.

14
a The girls went to the cinema to see a horror movie that was supposed to be really scary, but the movie was nothing but trivial. At the end of the show, one said to the other: “Oh that was really creepy! How about a drink?” and they went to a pub.
b The girls went to the cinema to see a horror movie that was supposed to be really scary, but the movie was even scarier than they had expected. At the end of the show, one said to the other: “Oh that was really creepy! How about a drink?” and they went to a pub.

c The girls went to the cinema to see a horror movie that was supposed to be really scary, but the movie was nothing but trivial. At the end of the show, one said to the other: “That was a waste of time. How about a drink?” and they went to a pub.

15

a Four friends are gambling in a casino. In the middle of the night one of them said: “I’ll bet my sports car to get my credit back”. They go outside to have a look at the car and they realise it’s just a Fiat Panda. One of the friends says: “Nice sports car” and they go back to the casino.

b Four friends are gambling in a casino. In the middle of the night one of them said: “I’ll bet my sports car to get my credit back”. They go outside to have a look at the car and they realise that it’s a vintage Ferrari. One of the friends says: “Nice sports car” and they go back to the casino.

c Four friends are gambling in a casino. In the middle of the night one of them said: “I’ll bet my sports car to get my credit back”. They go outside to have a look at the car and they realise that it’s just a Fiat Panda. One of the friends says: “That’s not a sports car” and they go back to the casino.

16

a Amelia and three friends had gone to London for the day. In the evening, she called home to ask her Dad to pick her up in Milton Keynes. She had taken the last train but forgot to check whether she would make the connection. Her father said, “You planned that very well” and then jumped in the car.

b Amelia and three friends had gone to London for the day. In the evening, she got home from the station by bus. She had taken the last train and made sure she would make the connection. Her father said, “You planned that very well” and then made her a cup of tea.

c Amelia and three friends had gone to London for the day. In the evening, she called home to ask her Dad to pick her up in Milton Keynes. She had taken the last train but forgot to check whether she would make the connection. Her father said, “I’ll be there in half an hour” and then jumped in the car.

17

a Leonard offers to show his new co-worker Karl around town. However, it quickly begins to rain heavily and they are forced to stay at a café without seeing any of the city. Karl tells Leonard, “What a fantastic city!” and they plan to meet again the following day weather permitting.

b Leonard offers to show his new co-worker Karl around town. The weather is nice and they see a lot of the city highlights. Afterwards, Karl tells Leonard, “What a fantastic city!” and they plan to meet again the following day for more exploring.

c Leonard offers to show his new co-worker Karl around town. However, it quickly begins to rain heavily and they are forced to stay at a café without seeing any of the city. Karl tells Leonard, “What a horrible weather!” and they plan to meet again the following day weather permitting.

18

a Oliver has gained weight and he decides to go see his doctor. The doctor puts him on a diet. One month after starting the diet, he hasn't lost any weight at all. Oliver goes to see his doctor again and he says: "This diet really works!" and he makes a new appointment for the following month.

b Oliver has gained weight and he decides to go see his doctor. The doctor puts him on a diet. One month after starting the diet, he has lost four pounds. Oliver goes to see his doctor again and he says: "This diet really works!" and he makes a new appointment for the following month.

c Oliver has gained weight and he decides to go see his doctor. The doctor puts him on a diet. One month after starting the diet, he hasn't lost any weight at all. Oliver goes to see his doctor again and he says: "This diet is not working!" and he makes a new appointment for the following month.

19

a While at a conference abroad, Peter runs into his colleague Tom. Tom asks him where the university cafeteria is. Peter offers to accompany him and Tom accepts. After looking for over an hour, they finally arrive at the cafeteria. Tom says, "Luckily we found this quickly" and they buy a sandwich.

b While at a conference abroad, Peter runs into his colleague Tom. Tom asks him where the university cafeteria is. Peter offers to accompany him and Tom accepts. Within just a few minutes, they arrive at the cafeteria. Tom says, "Luckily we found this quickly" and they buy a sandwich.

c While at a conference abroad, Peter runs into his colleague Tom. Tom asks him where the university cafeteria is. Peter offers to accompany him and Tom accepts. After looking for over an hour, they finally arrive at the cafeteria. Tom says, "Now I'm really hungry" and they buy a sandwich.

20

a At the party the hostess realised that one of her female guests had gained a lot of weight and was dressed in a track suit. When the guest approached her, the hostess said, "And you, my dear, elegant as ever!" and she looks her all over.

b At the party the hostess realised that one of her female guests had hardly changed in years and was immaculately dressed. When the guest approached her, the hostess said, "And you, my dear, elegant as ever!" and she looks her all over.

c At the party the hostess realised that one of her female guests had gained a lot of weight and was dressed in a track suit. When the guest approached her, the hostess said, "I'm so glad to see you here tonight!" and she looks her all over.

21

a Gemma and Steve have the same class this morning. They settle in and listen to the professor. The two students find the lecture uninteresting and tiresome. At the end, Gemma says to Steve, “The professor was captivating today” and they go out for a coffee.

b Gemma and Steve have the same class this morning. They settle in and listen to the professor. The two students find the lecture stimulating and interesting. At the end, Gemma says to Steve, “The professor was captivating today” and they go out for a coffee.

c Gemma and Steve have the same class this morning. They settle in and listen to the professor. The two students find the lecture uninteresting and tiresome. At the end, Gemma says to Steve, “The professor was tedious today” and they go out for a coffee.

22

a Josie is ill and asks her roommate to prepare her some herbal tea. Josie must stay in bed and rest all day. After drinking the tea, Josie feels even worse and ends up vomiting. Her roommate says, “This tea has really shown its effectiveness” and they decide to turn the TV on.

b Josie is ill and asks her roommate to prepare her some herbal tea. Josie must stay in bed and rest all day. After drinking the tea, Josie feels much better and starts to feel hungry. Her roommate says, “This tea has really shown its effectiveness” and they decide to turn the TV on.

c Josie is ill and asks her roommate to prepare her some herbal tea. Josie must stay in bed and rest all day. After drinking the tea, Josie feels even worse and ends up vomiting. Her roommate says, “This tea has not helped at all” and they decide to turn the TV on.

23

a Bob and Fiona find themselves on the same plane to New York. Both of them fly often. During the flight, they talk about their business trip. Just then, the pilot announces that their arrival will be delayed. Fiona says to Bob: “I’m impressed by their punctuality” and she decides to write an email.

b Bob and Fiona find themselves on the same plane to New York. Both of them fly often. During the flight, they talk about their business trip. Just then, the pilot announces that their arrival will be on time. Fiona says to Bob: “I’m impressed by their punctuality” and she decides to write an email.

c Bob and Fiona find themselves on the same plane to New York. Both of them fly often. During the flight, they talk about their business trip. Just then, the pilot announces that their arrival will be delayed. Fiona says to Bob: “I’m unimpressed by their punctuality” and she decides to write an email.

24

a Because he had to work, Brett came home late for dinner. His daughter had already eaten the whole cake that was for dessert, leaving him with just a few crumbs. Brett said: “Thanks for leaving me such a big piece!” and went to wash his hands.

b Because he had to work, Brett came home late for dinner. His daughter had already eaten some of the cake that was for dessert, but she left him a large slice. Brett said: “Thanks for leaving me such a big piece!” and went to wash his hands.
c Because he had to work, Brett came home late for dinner. His daughter had already eaten the whole cake that was for dessert, leaving him with just a few crumbs. Brett said: “I’m terribly sorry for being so late!” and went to wash his hands.

25
a The lecturer was marking assignments. One of these was absolutely awful, showing hardly any understanding of the topic and full of grammatical errors. The lecturer got a pen and wrote, “Great work!” at the bottom of the page.
b The lecturer was marking assignments. One of these was absolutely outstanding, showing excellent understanding of the topic and no grammatical errors whatsoever. The lecturer got a pen and wrote, “Great work!” at the bottom of the page.
c The lecturer was marking assignments. One of these was absolutely awful, showing hardly any understanding of the topic and full of grammatical errors. The lecturer got a pen and wrote, “This was bad!” at the bottom of the page.

26
a Tom was building an addition to his house. His younger brother was supposed to help, but he didn’t show up. At the end of a long day, when Tom’s brother finally appeared, Tom said, “Thanks for your help” and he put his tools back in the case.
b Tom was building an addition to his house. His younger brother was supposed to help and he did show up in time. At the end of a long day, when Tom’s brother finally finished, Tom said m, “Thanks for your help” and he put his tools back in the case.
c Tom was building an addition to his house. His younger brother was supposed to help, but he didn’t show up. At the end of a long day, when Tom’s brother finally appeared, Tom said, “I thought you were going to help” and he put his tools back in the case.

27
a The boy was playing football in the rain and the field was very muddy. When the game was over, he came back home. His clothes were terribly dirty. His mother said, “Thank you for keeping your clothes so clean!” and then she put the clothes in the washing basket.
b The boy was playing football on a dry sunny day and the field was very dry. When the game was over, he came back home. His clothes were not dirty at all. His mother said, “Thank you for keeping your clothes so clean!” and then she put the clothes in the washing basket.
c The boy was playing football in the rain and the field was very muddy. When the game was over, he came back home. His clothes were terribly dirty. His mother said, “I think you shouldn’t play football in the rain!” and then she put the clothes in the washing basket.

28
a Eve and Aline decide to go to a nightclub. Upon arriving they find that the music is out-dated and that the dance floor is empty. Alice turns to Eve and says: “The club is awesome tonight!” and then go back home.

b Eve and Aline decide to go to a nightclub. Upon arriving they find that the music is great and that the dance floor is full. Alice turns to Eve and says: “The club is awesome tonight!” and then go back home.
c Eve and Aline decide to go to a nightclub. Upon arriving they find that the music is out-dated and that the dance floor is empty. Alice turns to Eve and says: “This is not what I expected!” and then go back home.

29
a The book Sophia had been gifted was long and boring. The person who had given it to her asked, “Isn’t that a great novel?” Sophia replied, “An absolute treat” and ordered some wine for both of them.
b The book Sophia had been gifted was amazing and absorbing. The person who had given it to her asked, “Isn’t that a great novel?” Sophia replied, “An absolute treat” and ordered some wine for both of them.
c The book Sophia had been gifted was long and boring. The person who had given it to her asked, “Isn’t that a great novel?” Sophia replied, “I didn’t like it much” and ordered some wine for both of them.

30
a The family TV was many years old and had a crappy image. A friend of their son’s commented, “What a grand TV you have there!” and the son asked his parents to buy a new one immediately.
b The family TV was brand new and had 3D image. A friend of their son’s commented, “What a grand TV you have there!” and the son asked his parents to buy one for his room.
c The family TV was many years old and had a crappy image. A friend of their son’s commented, “What a cheap TV you have there!” and the son asked his parents to buy a new one immediately.

31
a Justin is helping his neighbour Brandon move. Justin is carrying large cardboard boxes. The boxes are so heavy that Justin hardly manages to lift them. He says to Brandon: “I’m glad you didn’t overpack these boxes” and Brandon thanks Justin for all his help.
b Justin is helping his neighbour Brandon move. Justin is carrying large cardboard boxes. The boxes are quite light and Justin easily manages to lift them. He says to Brandon: “I’m glad you didn’t overpack these boxes” and Brandon thanks Justin for all his help.
c Justin is helping his neighbour Brandon move. Justin is carrying large cardboard boxes. The boxes are so heavy that Justin hardly manages to lift them. He says to Brandon: “You really overpacked these boxes” and Brandon thanks Justin for all his help.

32
a Michael and Jim go fishing together once a year in a lake. As usual, they talk while waiting for the fish to bite. At the end of the day, neither of them managed to catch a single fish. As they were leaving, Michael told Jim: “Good fishing today” and they returned home.

b Michael and Jim go fishing together once a year in a lake. As usual, they talk while waiting for the fish to bite. At the end of the day, both of them managed to catch lots of fish. As they were leaving, Michael told Jim: “Good fishing today” and they returned home.

c Michael and Jim go fishing together once a year in a lake. As usual, they talk while waiting for the fish to bite. At the end of the day, neither of them managed to catch a single fish. As they were leaving, Michael told Jim: “Worst fishing ever” and they returned home.

33

a The little chiwawa was barking menacingly at the visitors. One of them said, “I’m scared of that enormous beast” and then its owner decided to give it a treat.

b The giant Rottweiler was barking menacingly at the visitors. One of them said, “I’m scared of that enormous beast” and then its owner decided to give it a treat.

c The little chiwawa was barking menacingly at the visitors. One of them said, “I hope it will stop yapping soon” and then its owner decided to give it a treat.

Table 32 - Percentage of errors in the sentence interpretation task - Irony Experiment – patient group

PARTICIPANTS	IRONY PROCESSING ERROR PERCENTAGE
1	0
2	50
3	23
4	91.5
5	9
6	75
7	27
8	4
9	14
10	25
11	14
12	42
13	14
14	75
15	96
16	50
17	83
18	25
19	20
20	91
21	10
22	70
23	60
24	15
25	59
MEAN	41.7

Table 33 - Percentage of errors in the sentence interpretation task - Irony Experiment – control group

PARTICIPANTS	IRONY PROCESSING ERROR PERCENTAGE
1	10
2	16.6
3	0
4	0
5	4
6	0
7	5
8	8.3
9	33.3
10	0
11	0
12	8.3
13	10
14	18
15	41.6
16	5
17	0
18	23
19	10
20	32
21	41.6
MEAN	12.7

Irony Analysis in R

```
#read in file

data = read.csv(file.choose(), header = T)
head(data)

library(lme4)
library(languageR)
library(lmerTest)
library(MASS)
library(cAIC4)
library(ggplot2)

data$subj <- factor(data$subj)
data$item <- factor(data$item)
data$group <- factor(ifelse(data$patient_control == 1, "PwS",
 "Control"))
data$cond = as.factor(data$cond)
data$LogFPtarget<-log(data$fptarget)
data$LogRPtarget<-log(data$Rptarget)
data$fptarget <- as.numeric(as.character(data$fptarget))
data$rptarget <- as.numeric(as.character(data$Rptarget))
data$rpspill <- as.numeric(as.character(data$Rpspill))
data$LogRPspill<-log(data$Rpspill)
data$tttarget <- as.numeric(as.character(data$tttarget))
data$LogTTtarget<-log(data$tttarget)
data$ttspill <- as.numeric(as.character(data$ttspill))
data$LogTTspill<-log(data$ttspill)
data$sptarget <- as.numeric(as.character(data$SecPtarget))
data$LogSPtarget <- as.numeric(as.character(data$LogSPtarget))
```

```
data$ritarget <- as.numeric(as.character(data$ritarget))


tapply(data$fptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$rptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$LogFPtarget, list(data$group, data$cond), na.rm =
 TRUE, mean)



Myplot<-ggplot(data,aes(x=cond,y=fptarget))+geom_point()

Myplot<-Myplot + geom_smooth(method="lm")

Myplot+ geom_point(aes(colour = factor(group)), size=2)



#FP all conds

M1 = lmer(data = data, LogFPtarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, LogFPtarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, LogFPtarget ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, LogFPtarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#RP all conds
```

```
M1 = lmer(data = data, rptarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, rptarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, rptarget ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, rptarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))


M1 = lmer(data = data, LogRPspill ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, LogRPspill ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, LogRPspill ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, LogRPspill ~ cond  + (1+cond|subj) +
 (1+cond+group|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#TT

M1 = lmer(data = data, tttarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, tttarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, tttarget ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, tttarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))
```

```
M1 = lmer(data = data, LogTTtarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, LogTTtarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, LogTTtarget ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, LogTTtarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))


M1 = lmer(data = data, ttspill ~ group * cond  + (1+cond|subj)
 + (1+cond|item))

M2 = lmer(data = data, ttspill ~ group + cond  + (1+cond|subj)
 + (1+cond|item))

M3 = lmer(data = data, ttspill ~ group + (1+cond|subj) +
 (1+cond|item))

M4 = lmer(data = data, ttspill ~ cond  + (1+cond|subj) +
 (1+cond|item))


M1 = lmer(data = data, LogTTspill ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTspill ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTspill ~ group + (1+cond|subj) +
 (1+cond|item))

M4 = lmer(data = data, LogTTspill ~ cond  + (1+cond|subj) +
 (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#SP
```

```
M1 = glmer(data = data, sptarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M2 = glmer(data = data, sptarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M3 = glmer(data = data, sptarget ~ group  + (1+cond|subj) +
 (1+cond|item), family="poisson")

M4 = glmer(data = data, sptarget ~ cond  + (1+cond|subj) +
 (1+cond|item), family="poisson")

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#log does not work - substitute by hand

M1 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M2 = glmer(data = data, LogSPtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M3 = glmer(data = data, LogSPtarget ~ group  + (1+cond|subj) +
 (1+cond|item), family="poisson")

M4 = glmer(data = data, LogSPtarget ~ cond  + (1+cond|subj) +
 (1+cond|item), family="poisson")

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#RI

M1 = lmer(data = data, ritarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))
```

```
M2 = lmer(data = data, ritarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, ritarget ~ group  + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, ritarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)




#####

lit_iro<-data[data$condLI == 1,]

head(lit_iro)


tapply(lit_iro$fptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)


M1 = lmer(data = lit_iro, LogTTtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = lit_iro, LogTTtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = lit_iro, LogTTtarget ~ group + (1+cond|subj)
 + (1+cond|item))

M4 = lmer(data = lit_iro, LogTTtarget ~ cond  + (1+cond|subj)
 + (1+cond|item))

#interaction significant?

anova(M1,M2)


#cond significant?

anova(M2,M3)
```

```
#group significant?
anova(M2,M4)

summary(M1)

### Groups separately

irony_PwS<-data[data$group == "PwS",]
head(irony_PwS)

M1 = lmer(data = irony_PwS, LogTTtarget ~ cond  +
 (1+cond|subj) + (1+cond|item))
summary(M1)

irony_Controls<-data[data$group == "Control",]
head(irony_Controls)

M1 = lmer(data = irony_Controls, tttarget ~ cond  +
 (1+cond|subj) + (1+cond|item))
summary(M1)
```

APPENDIX D

Metaphor Pre-Testing

Condition 1 - Metaphors

Item	Condition	Sentences	Sensicality (1/Y – 0/N)	Ease of Understandin g (1-7)	Literalness (1/Y-0/N)	Familiarit y (1-7)	Predictability (Number of participants)
1	1	Laura affirmed that the detective was a pig	0.95	5.77	0.09	5.48	0
2	1	Jacqueline claims that her life is a fashion show	1	6.14	0.77	5.45	0
3	1	Sam is convinced that the world is a stage	1	6.32	0	6.36	1
4	1	It's obvious that Gregory's bedroom is a disaster area	0.95	5.86	0.14	5.4	0
7	1	It's true that some mouths are sewers	0.82	4.5	0.09	4.1	0
8	1	It's indeed the case that some lawyers are sharks	1	6.18	0.77	6.41	0
10	1	Apparently, Joan's smile was a mask	1	6.14	0.14	6.1	0
12	1	Ricardo thinks his new girlfriend is a toy	1	6.23	0	5.27	0
13	1	According to Rachel, the woman is a snake	0.82	5.09	0.14	4.33	0
11	1	It seems to me that Tom's heart is a stone	0.95	6.09	0.73	5.95	3

15	1	It is reported that the cheating husband is a worm	0.95	5.91	0	5.04	0
16	1	Jim said that the promotion is a ladder	0.86	4.5	0.09	4.5	0
19	1	It is well known that some jobs are jails	0.86	4.95	0.14	4.68	0
20	1	Jim claims that his profession is a rat race	0.86	5.23	0.73	5.4	0
21	1	Julie believes that the toddler is an angel	1	6.40	0	6.63	0
22	1	It's obvious that some adults are babies	0.91	5.54	0.09	5.21	0
24	1	We heard that Joe's surgeon is a butcher	0.95	5.73	0.23	5.61	0
25	1	It is well known that words are weapons	1	6.32	0.14	5.94	2
26	1	As we all expected, the lecturer was a dragon	0.91	5.45	0.68	4.86	0
27	1	As we expected, university was a journey	1	6.73	0.04	6.66	0
28	1	Mary whispered to us that the relationship was a prison	0.09	1.82	0.76	1.87	0
29	1	Apparently, her eyes were fireflies	0.82	4.59	0.63	3.77	0
30	1	Apparently, the job fair was a circus	1	6.23	0	5.68	0
33	1	I'm not surprised to hear that the grandfather is a fossil	0.86	5.32	0.04	4.81	0
34	1	It's often remarked that that politician is an actor	1	6.27	0.5	5.25	0
35	1	Apparently, the love affair is a rollercoaster	0.91	6.09	0.68	6.24	0

40	1	It seemed that their family was a mighty fortress	0.82	4.5	0.18	3.2	0
42	1	Luckily, the goalkeeper was a centipede	0.64	3.91	0.04	2.43	0
43	1	I'm aware that the woman is a whale	0.91	5.64	0.04	5.71	0
44	1	It looks like her teeth are pearls	1	6.32	0.77	6.25	0
38	1	It's obvious that his wife was his compass	0.91	4.95	0.68	4.14	0
46	1	Fiona claims that corruption is a virus	1	5.86	0.18	4.82	0
23	1	I was told that the movie was a treat	1	6.59	0.82	6.07	0
		average metaphors	0.90	5.55			
		standard deviation metaphors	0.17	0.97			

Condition 2 - Literals

Item	Condition	Sentences	Sensicality (1/Y – 0/N)	Ease of Understanding (1-7)	Literalness (1/Y-0/N)	Familiarity (1-7)	Predictability score (Number of participants)
1	2	Laura affirmed that the creature was a pig	0.95	6.64	0.95	5.43	0
2	2	Jacqueline claims that her event is a fashion show	1	6.95	0.95	6.8	0
3	2	Sam is convinced that the floor is a stage	0.86	4.63	0.45	3.73	0
4	2	It's obvious that Gregory's village is a disaster area	0.91	5.73	0.91	4.78	0
7	2	It's true that some tunnels are sewers	0.95	5.68	0.95	5.43	0
8	2	It's indeed the case that some animals are sharks	0.95	6	0.91	4.6	0
10	2	Apparently, Joan's gift was a mask	0.95	5.77	0.95	4.7	0
12	2	Ricardo thinks his new present is a toy	1	6.68	0.82	6.12	0
13	2	According to Rachel, the animal is a snake	0.95	6.41	0.95	4.62	2
11	2	It seems to me that Tom's weapon is a stone	1	6.73	1	6	0
15	2	it is reported that the crawling insect is a worm	0.82	5.64	0.91	4.67	0
16	2	Jim said that the apparatus is a ladder	0.95	6.18	0.95	5.43	0
19	2	It is well known that some buildings are jails	1	6.45	1	5	0

20	2	Jim claims that his experiment is a rat race	1	6.04	0.48	5.15	0
21	2	Julie believes that the spirit is an angel	1	5.82	0.68	4.45	0
22	2	It's obvious that some infants are babies	0.77	5.04	0.77	4.37	0
24	2	We heard that Joe's neighbour is a butcher	1	6.82	0.95	5.17	0
25	2	It is well known that knives are weapons	1	6.91	1	6.86	0
26	2	As we all expected, the symbol was a dragon	0.95	6.27	0.86	4.4	0
27	2	As we expected, flying is a journey	0.82	4.59	0.68	3.73	0
28	2	Mary whispered to us that the hospital was a prison	1	6.45	0.77	5.73	0
29	2	Apparently, the bugs were fireflies	1	6.95	1	4.67	0
30	2	Apparently, the big tent was a circus	0.95	6	0.91	4.33	0
33	2	I'm not surprised to hear that the skeleton is a fossil	1	6.18	0.86	5	0
34	2	It's often remarked that that performer is an actor	0.95	6.18	0.95	5.71	1
35	2	Apparently, the attraction is a rollercoaster	0.91	6.18	0.86	3.83	0
40	2	It seemed that their temple was a mighty fortress	0.95	5.95	0.77	4.94	0
42	2	Luckily, the insect was a centipede	0.95	6.72	0.95	5.58	1
43	2	I'm aware that the animal is a whale	0.95	6.64	0.95	6.33	0
44	2	It looks like her earrings are pearls	1	6.95	0.95	7	0

38	2	It's obvious that his tool was his compass	1	6.23	0.86	5	0
46	2	Fiona claims that influenza is a virus	1	6.90	1	6.75	0
23	2	I was told that the cake was a treat	1	6.64	0.91	6.5	3
		average literals	0.96	6.21	0.88	5.24	0.21
		standard deviation literals	0.06	0.62	0.14	0.92	0.65
		t-test(metaphor and literal means)	0.10	0.004	5.65	0.72	0.85

Condition 3 – Nonsense

Item	Condition	Sentences	Sensicality (1/Y – 0/N)	Ease of Understanding (1-7)	Literalness (1/Y-0/N)	Familiarity (1-7)	Predictability score (Number of participants)
1	3	Laura affirmed that the suitcase was a pig	0.32	3.23	0.09	2.2	0
2	3	Jacqueline claims that her train is a fashion show	0.36	2.4	0.14	1.9	0
3	3	Sam is convinced that the chair is a stage	0.23	2.5	0.14	1.95	0
4	3	It's obvious that Gregory's article is a disaster area	0.82	4.68	0.09	4.38	0
7	3	It's true that some lamps are sewers	0	2.09	0.14	1.28	0
8	3	It's indeed the case that some machines are sharks	0.41	2.82	0.27	2.70	0
10	3	Apparently, Joan's fork was a mask	0.14	2.14	0.14	1.37	0
12	3	Ricardo thinks his new chapter is a toy	0.09	1.82	0.04	1.62	0
13	3	According to Rachel, the glass is a snake	0.27	2.95	0.09	1.55	0
11	3	It seems to me that Tom's bottle is a stone	0.04	1.77	0.32	1.5	0
15	3	It is reported that the expensive pencil is a worm	0.04	1.64	0.09	1.05	0
16	3	Jim said that the machine is a ladder	0.41	3.04	0.52	2	0
19	3	It is well known that some experts are jails	0.09	2.04	0.05	1.22	0
20	3	Jim claims that his connection is a rat race	0.45	3.27	0.18	3.33	0
21	3	Julie believes that the screen is an angel	0.18	2.18	0.09	2.05	0
22	3	It's obvious that some valleys are babies	0.09	2.45	0.09	1.8	0
24	3	We heard that Joe's teacher is a butcher	0.81	5.04	0.73	4.25	0
25	3	It is well known that shoes are weapons	0.64	4.64	0.41	1.75	0

26	3	As we all expected, the finger was a dragon	0.09	1.68	0.36	1.31	0
27	3	As we all expected, community is a journey	0.27	2.18	0.18	1.90	0
28	3	Mary whispered to us that the bookcase was a prison	0.68	3.68	0.04	2.38	0
29	3	Apparently, the cups were fireflies	0.14	1.95	0.41	1.2	0
30	3	Apparently, the huge wall was a circus	0.14	2.14	0.14	1.57	0
33	3	I'm not surprised to hear that the construction is a fossil	0.23	2.59	0.27	2.12	0
34	3	It's often remarked that that designer is an actor	0.82	4.90	0.67	3.44	0
35	3	Apparently, the loudspeaker is a rollercoaster	0.09	1.82	0.27	1.47	0
40	3	It seemed that their drawer was a mighty fortress	0.54	3.68	0.04	3.05	0
42	3	Luckily, the reporter was a centipede	0.18	2.5	0.14	1.55	0
43	3	I'm aware that the night is a whale	0.09	1.82	0.05	1.4	0
44	3	It looks like her clothes are pearls	0.73	4.14	0.18	3.44	0
38	3	It's obvious that his spoon was his compass	0.36	3	0.36	2.41	0
46	3	Fiona claims that dampness is a virus	0.68	4.04	0.36	2.4	2
23	3	I was told that the sound was a treat	0.68	4.13	0.36	3.72	0
		average non-sensicals	0.34	2.88	0.23	2.16	0.06
		standard deviation non-sensicals	0.26	1.03	0.18	0.91	0.35
		t-test (literal and non-sensical means)	2.90	2.41	2.22	2.17	0.26

Metaphor Eye-tracking stimuli.

In the first version (a) of each item the fragment is used metaphorically. In the second version (b) it is used literally. In the third version (c) it is used nonsensically.

1.

a. Laura affirmed that the detective was a pig and that she was not happy with that. She decided not to let it ruin her day and tried to think of happier thoughts. After a good night’s sleep, she no longer cared.

b Laura affirmed that the creature was a pig and that she was not happy with that. She decided not to let it ruin her day and tried to think of happier thoughts. After a good night's sleep, she no longer cared.

c Laura affirmed that the suitcase was a pig and that she was not happy with that. She decided not to let it ruin her day and tried to think of happier thoughts.

2.

a Jacqueline claims that her life is a fashion show and that she will enjoy it. She spends most of her time shopping and enjoys wearing new clothes. Her dream job is to be a model, but she is afraid that she doesn’t have the right looks.

b Jacqueline claims that her event is a fashion show and that she will enjoy it. She spends most of her time shopping and enjoys wearing new clothes. Her dream job is to be a model, but she is afraid that she doesn't have the right looks.

c Jacqueline claims that her train is a fashion show and that she will enjoy it. She spends most of her time shopping and enjoys wearing new clothes. Her dream job is to be a model, buth she is afraid that she doesn't have the right looks.

3.

a Sam is convinced that the world is a stage, but I’m sure that not everyone thinks that. He has explained this to many of his friends. They tend to give him wary looks in response because Sam often makes mistakes.

b Sam is convinced that the floor is a stage, but I’m sure that not everyone thinks that. He has explained this to many of his friends. They tend to give him wary looks in response because Sam often makes mistakes.
c Sam is convinced that the chair is a stage, but I’m sure that not everyone thinks that. He has explained this to many of his friends. They tend to give him wary looks in response because Sam often makes mistakes.

4.
a It’s obvious that Tim’s bedroom is a disaster area and that it will take time to make it right again. If Gregory keeps ignoring this fact then it will only get worse.
b It’s obvious that Tim’s village is a disaster area and that it will take time to make it right again. If Tim keeps ignoring this fact then it will only get worse.
c It’s obvious that Tim’s article is a disaster area and that it will take time to make it right again. If Gregory keeps ignoring this fact then it will only get worse.

5.
a It’s true that some mouths are sewers, as Jonathan said. He likes to talk to people about this matter. Unfortunately, none of his friends enjoy listening to him.
b It’s true that some tunnels are sewers, as Jonathan said. He likes to talk to people about this matter. Unfortunately, none of his friends enjoy listening to him.
c It’s true that some lamps are sewers, as Jonathan said. He likes to talk to people about this matter. Unfortunately, none of his friends enjoy listening to him.

6.
a It’s indeed the case that some lawyers are sharks, as Bob’s mom claimed before. The first time she said this, Bob wasn’t listening. He was too busy thinking about how much he liked sharks and where the nearest aquarium was located.
b It’s indeed the case that some animals are sharks, as Bob’s mom claimed before. The first time she said this, Bob wasn't listening. He was too busy thinking about how much he liked sharks and where the nearest aquarium was located.
c It’s indeed the case that some machines are sharks, as Bob’s mom claimed before. The first time she said this, Bob wasn't listening. He was too busy thinking about how much he liked sharks and where the nearest aquarium was located.

7.

a Apparently, Joan’s smile was a mask, as Rosie had mentioned before. Joan and Rosie are good friends. That is why Rosie knew about it.

b Apparently, Joan’s gift was a mask, as Rosie had mentioned before. Joan and Rosie are good friends. That is why Rosie knew about it.
c Apparently, Joan’s fork was a mask, as Rosie had mentioned before. Joan and Rosie are good friends. That is why Rosie knew about it.

8.
a It seems to me that Tom’s heart is a stone and everybody would agree. It is really a shame. Since he was a baby he has always been so properly nurtured and cared for.
b It seems to me that Tom’s weapon is a stone and everybody would agree. It is really a shame. Since he was a baby he has always been so properly nurtured and cared for.
c It seems to me that Tom’s bottle is a stone and everybody would agree. It is really a shame. Since he was a baby he has always been so properly nurtured and cared for.

9.
a Ricardo thinks his new girlfriend is a toy, and he’s happy with it. His mother has demanded that he acts more maturely. Ricardo usually ignores his mother's demands because he thinks she complains too much.
b Ricardo thinks his new present is a toy, and he’s happy with it. His mother has demanded that he acts more maturely. Ricardo usually ignores his mother's demands because he thinks she complains too much.
c Ricardo thinks his new chapter is a toy, and he’s happy with it. His mother has demanded that he acts more maturely. Ricardo usually ignores his mother’s demands because he thinks she complains too much.

10.
a According to Rachel, the woman is a snake and nobody can do a thing about that. Everybody is afraid. It is really too bad we can’t get rid of her.
b According to Rachel, the animal is a snake and nobody can do a thing about that. Everybody is afraid. It is really too bad we can't get rid of it.
c According to Rachel, the glass is a snake and nobody can do a thing about that. Everybody is afraid. It is really too bad we can’t get rid of it.

11.
a It is reported that the cheating husband is a worm but I wonder if it is true. There have been so many discussions on the matter. One thing is true, however, nobody likes worms.

b It is reported that the crawling insect is a worm but I wonder if it is true. There have been so many discussions on the matter. One thing is true, however, nobody likes worms.
c It is reported that the expensive pencil is a worm but I wonder if it is true. There have been so many discussions on the matter. One thing is true, however, nobody likes worms.

12
a Jim said that the promotion is a ladder and that he would use it. He would be silly not to. Many have warned him to be cautious, but Jim has decided not to listen to them.
b Jim said that the apparatus is a ladder and that he would use it. He would be silly no to. Many have warned him to be cautious, but Jim has decided not to listen to them.
c Jim said that the machine is a ladder and that he would use it. He would be silly not to. Many have warned him to be cautious, but Jim has decided not to listen to them.

13
a It is well known that some jobs are jails and that nobody wants to work in such places. Unfortunately, some people can't be picky. They must work where they can because they have children to support.
b It is well known that some buildings are jails and that nobody wants to work in such places. Unfortunately, some people can't be picky. They must work where they can because they have children to support.
c It is well known that some experts are jails and that nobody wants to work in such places. Unfortunately, some people can’t be picky. They must work where they can because they have children to support.

14
a Tim claims that his profession is a rat race and that he is no longer happy with that. He decided to stop what he is doing. Some people might be upset with Jim and his absence, but he needs a break to decide what to do next.
b Tim claims that his experiment is a rat race and that he is no longer happy with that. He decided to stop what he is doing. Some people might be upset with Jim and his absence, but he needs a break to decide what to do next.
c Tim claims that his connection is a rat race and that he is no longer happy with that. He decided to stop what he is doing. Some people might be upset with Jim and his absence, but he needs a break to decide what to do next.

15
a Julie believes that the toddler is an angel and that she needs to comfort him. As she is a caring person, it will be easy for her. She enjoys looking after others and believes this will be no different.

b Julie believes that the spirit is an angel and that she needs to comfort it. As she is a caring person, it will be easy for her. She enjoys looking after others and believes this will be no different.
c Julie believes that the screen is an angel and that she needs to comfort it. As she is a caring person, it will be easy for her. She enjoys looking after others and believes this will be no different.

16
a It's obvious that some adults are babies, as Mary said. I strongly agree with her. In fact, I know a few although I wish I didn't. I try to spend most of my time with mature family members instead.
b It's obvious that some infants are babies, as Mary said. I strongly agree with her. In fact, Iknow a few although I wish I didn't. I try to spend most of my time with mature family members instead.
c It's obvious that some valleys are babies, as Mary said. I strongly agree with her. In fact, I know a few although I wish I didn't. I try to spend most of my time with mature family members instead.

17
a We heard that Joe's surgeon is a butcher and that he is afraid of him. Joe is a nervous man and tends to avoid most people. However, we think he is right to be afraid.
b We heard that Joe's neighbour is a butcher and that he is afraid of him. Joe is a nervous man and tends to avoid most people. However, we think he is right to be afraid.
c We heard that Joe's teacher is a butcher and that he is afraid of him. Joe is a nervous man and tends to avoid most people. However, we think he is right to be afraid.

18
a I was told that the movie was a treat for the children and that they really enjoyed it. It feels wonderful to be able to go out with the children on a Sunday afternoon.
b I was told that the cake was a treat for the children and that they really enjoyed it. It feels wonderful to be able to go out with the children on a Sunday afternoon.
c I was told that the sound was a treat for the children and that they really enjoyed it. It feels wonderful to be able to go out with the children on a Sunday afternoon.

19
a It is well known that words are weapons, as Robbie pointed out. Sarah was unsure why Robbie had brought this up. It made her wary, and she decided to go back home on her own.

b It is well known that knives are weapons, as Robbie pointed out. Sarah was unsure why Robbie had brought this up. It made her wary, and she decided to go back home on her own.
c It is well known that shoes are weapons, as Robbie pointed out. Sarah was unsure why Robbie had brought this up. It made her wary, and she decided to go back home on her own.

20
a As we all expected, the lecturer was a dragon and we would have to tolerate that. It is surprising that nobody felt like complaining about that. If people weren't so tolerant, a lot of complaints would have been made by now.
As we all expected, the symbol was a dragon and we would have to tolerate that. It is surprising that nobody has felt like complaining about that. If people weren't so tolerant, a lot of complaints would have been made by now.
As we all expected, the finger was a dragon and we would have to tolerate that. It is surprising that nobody has felt like complaining about that. If people weren’t so tolerant, a lot of complaints would have been made by now.

21

a As we expected, university is a journey, and we had to go through it. We meet many people along the way. Some of them will become friends, but most of them we will never see again.

b As we expected, flying is a journey, and we had to go through it. We meet many people along the way. Some of them will become friends, but most of them we will never see again.

c As we expected, community is a journey, and we had to go through it. We met many people along the way. Some of them will become friends, but most of them we will never see again.

22

a Mary whispered to us that the relationship was a prison and that she hated it. But she wouldn't dare to escape. Her mom told her that she would not support her if she decided to leave.

b Mary whispered to us that the hospital was a prison and that she hated it. But she wouldn't dare to escape. Her mom told her that she would not support her if she decided to leave.

c Mary whispered to us that the bookcase was a prison and that she hated it. But she wouldn't dare to escape. Her mom told her that she would not support her if she decided to leave.

23

a Apparently, her eyes were fireflies, as we could notice. We waited to get a better look because they were too far away at that moment.

b Apparently, the bugs were fireflies, as we could notice. We waited to get a better look because they were too far away at that moment.

c Apparently, the cups were fireflies, as we could notice. We waited to get a better look because they were too far away at that moment.

24

a Apparently, the job fair was a circus, as we could soon find out. We had to follow the signs, but it wasn't long before we arrived.

b Apparently, the big tent was a circus, as we could soon find out. We had to follow the signs, but it wasn't long before we arrived. It was very exciting to see what there was waiting for us.

c Apparently, the huge wall was a circus, as we could soon find out. We had to follow the signs but it wasn't long before we arrived. It was very exciting to see what there was waiting for us.

25

a I'm not surprised to hear that the grandfather is a fossil, as Jenny had pointed out. That's what happens over time. Nobody can help it.

b I'm not surprised to hear that the skeleton is a fossil, as Jenny had pointed out. That's what happens over time. Nobody can help it.

c I'm not surprised to hear that the construction is a fossil, as Jenn had pointed out. That's what happens over time. Nobody can help it.

26.

a It's often remarked that this politician is an actor, even though he might not like that term. It provides the perfect description of his behaviour.

b It's often remarked that this performer is an actor, even though he might not like that term. It provides the perfect description of his behaviour.

c It's often remarked that this designer is an actor, even though he might not like that term. It provides the perfect description of his behaviour.

27
a Luckily, the goalkeeper was a centipede and delighted everyone in attendance. We don't often see things like that.
b Luckily, the insect was a centipede and delighted everyone in attendance. We don't often see things like that.
c Luckily, the reporter was a centipede and delighted everyone in attendance. We don't often see things like that.

28
a Apparently, the love affair is a rollercoaster, as John pointed out. He knows now he has to be worried about the ups and downs in order not to get hurt.
b Apparently, the attraction is a rollercoaster, as John pointed out. He knows now he has to be worried about the ups and downs in order not to get hurt.
c Apparently, the loudspeaker is a rollercoaster, as John pointed out. He knows now he has to be worried about the ups and downs in order not to get hurt.

29
a It's obvious that his wife was his compass, as Jennie had mentioned. They are inseparable and have been for many years.
b It's obvious that his tool was his compass, as Jennie had mentioned. They are inseparable and have been together for many years.
c It's obvious that his spoon was his compass, as Jennie had mentioned. They are inseparable and have been for many years.

30
a It seemed that their family was a mighty fortress, as Margaret observed. Regardless of what happened, Margaret was always welcome whenever she needed.
b It seemed that their temple was a mighty fortress, as Margaret observed. Regardless of what happened, Margaret was always welcome whenever she needed.
c It seemed that their drawer was a mighty fortress, as Margaret observed. Regardless of what happened, Margaret was always welcome whenever she needed.

31
a I'm aware that the woman is a whale, but you should keep your voice down. People can get very upset at the aquarium when you say things too loudly. You should be quiet.

b I'm aware that the animal is a whale, but you should keep your voice down. People can get very upset when you say things too loudly. You should be quiet.
c I'm aware that the night is a whale, but you should keep your voice down. People can get very upset when you say things too loudly. You should be quiet.

32
a It looks like her teeth are pearls now; she must have had something done to them. She probably wanted to treat herself because she is going out to a party later tonight.
b It looks like her earrings are pearls now; she must have had something done to them. She probably wanted to treat herself because she is going out to a party.
c It looks like her clothes are pearls now; she must have had something done to them. She probably wanted to treat herself because she is going out to a party later on tonight.

33
a Fiona claims that corruption is a virus and that it can cause widespread damage. She hates hearing about the horrible things happening around the world, it makes her feel sad.
b Fiona claims that influenza is a virus and that it can cause widespread damage. She hates hearing about the horrible things happening around the world. It makes her feel sad.
c Fiona claims that dampness is a virus and that it can cause widespread damage. She hates hearing about the horrible things happening around the world, it makes her feel sad.

Table 34 - Percentage of errors in the sentence interpretation task - Metaphor Experiment – patient group

Participant	*Percentage of Errors in Metaphor Processing*	*Percentage of Errors in Literal Processing*	*Percentage of Errors in Nonsense Processing*
1	16	26	63
2	21	0	10.5
3	0	10.5	10.5
4	63	21	31.5
5	52	21	63
6	52	52	63
7	0	42	10.5
8	10.5	42	42
9	0	0	0
10	31.5	31.5	10.5
11	21	21	73.5
12	84	42	31.5
13	42	31.5	63
14	42	10.5	42
15	84	31.5	10.5
16	73	0	42
17	47	31.5	21
18	0	6	26
19	31.5	36	21
20	68	31.5	10.5
21	47	16	63
22	31.5	10.5	58
23	84	0	0
24	68	21	10.5
25	10.5	31.5	63
Mean(SD)	*39.18(28.16)*	*22.7(15.1)*	*33.6(24.1)*

Table 35 - Percentage of errors in the sentence interpretation task – Metaphor Experiment - control group

Participant	*Percentage of Errors in Metaphor Processing*	*Percentage of Errors in Literal Processing*	*Percentage of Errors in Nonsense Processing*
1	0	10.5	10.5
2	52.5	42	10.5
3	10.5	10.5	31.5
4	42	0	10.5
5	10.5	0	10.5
6	84	10.5	10.5
7	10.5	0	52.5
8	0	10.5	42
9	0	0	26
10	10.5	0	21
11	31.5	0	21
12	42	0	21
13	0	0	31.5
14	0	0	21
15	0	0	0
16	0	0	0
17	10.5	10.5	42
18	0	10.5	21
19	10.5	0	10.5
20	10.5	10.5	52.5
21	0	0	0
Mean(SD)	*15.5(22.42)*	*5.5(9.75)*	*21.24(15.96)*

Metaphor Analysis in R

```
#read in file metaphor_final.csv

data = read.csv(file.choose(), header = T)
head(data)

library(lme4)
library(languageR)
library(lmerTest)
library(MASS)
library(cAIC4)
library(ggplot2)
library(plyr)

citation()

data$subj <- factor(data$subj)
data$item <- factor(data$item)
data$group <- factor(ifelse(data$patient_control == 1, "PwS",
 "Control"))
data$cond <- factor(data$cond)
data$LogFPtarget<-
 as.numeric(as.character(data$LogFPtarget),na.rm = TRUE)
data$LogFPspill<-
 as.numeric(as.character(data$LogFPspill),na.rm = TRUE)
data$LogRPtarget<-
 as.numeric(as.character(data$LogRPtarget),na.rm = TRUE)
data$LogRPspill<-
 as.numeric(as.character(data$LogRPspill),na.rm = TRUE)
data$LogTTtarget<-
 as.numeric(as.character(data$LogTTtarget),na.rm = TRUE)
data$LogTTspill<-
```

```
as.numeric(as.character(data$LogTTspill),na.rm = TRUE)
data$LogSPtarget <-
as.numeric(as.character(data$LogSPtarget),na.rm = TRUE)
data$LogSPspill <-
as.numeric(as.character(data$LogSPspill),na.rm = TRUE)

data$fptarget <- as.numeric(as.character(data$fptarget))
data$rptarget <- as.numeric(as.character(data$rptarget))
data$fpspill <- as.numeric(as.character(data$fpspill))
data$rpspill <- as.numeric(as.character(data$rpspill))
data$tttarget <- as.numeric(as.character(data$tttarget))
data$ttspill <- as.numeric(as.character(data$ttspill))
data$ritarget <- as.numeric(as.character(data$ritarget))
data$rispill <- as.numeric(as.character(data$rispill))

tapply(data$fptarget, list(data$group, data$cond), na.rm =
TRUE, mean)
tapply(data$fptarget, list(data$cond), na.rm = TRUE, mean)
tapply(data$fpspill, list(data$group, data$cond), na.rm =
TRUE, mean)
tapply(data$fpspill, list(data$cond), na.rm = TRUE, mean)

tapply(data$rptarget, list(data$group, data$cond), na.rm =
TRUE, mean)
tapply(data$rptarget, list(data$cond), na.rm = TRUE, mean)
tapply(data$rpspill, list(data$group, data$cond), na.rm =
TRUE, mean)
tapply(data$rpspill, list(data$cond), na.rm = TRUE, mean)

tapply(data$ritarget, list(data$group, data$cond), na.rm =
TRUE, mean)
tapply(data$ritarget, list(data$cond), na.rm = TRUE, mean)
tapply(data$rispill, list(data$group, data$cond), na.rm =
TRUE, mean)
```

```
tapply(data$rispill, list(data$cond), na.rm = TRUE, mean)


tapply(data$tttarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$tttarget, list(data$cond), na.rm = TRUE, mean)

tapply(data$ttspill, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$ttspill, list(data$cond), na.rm = TRUE, mean)


Myplot<-ggplot(data,aes(x=cond,y=LogFPtarget))+geom_point()

Myplot<-Myplot + geom_smooth(method="lm")

Myplot+ geom_point(aes(colour = factor(group)), size=2)


M1 = lmer(data = data, fptarget ~ group * cond +
 (1+cond|subj) + (1+cond|item))


#FP max model all conds; does not work, decorrelate

#M1 = lmer(data = data, fptarget ~ group * cond +
 (1+cond|subj) + (1+cond|item))

#M2 = lmer(data = data, fptarget ~ group + cond +
 (1+cond|subj) + (1+cond|item))

#M3 = lmer(data = data, fptarget ~ group + (1+cond|subj) +
 (1+cond|item))

#M4 = lmer(data = data, fptarget ~ cond + (1+cond|subj) +
 (1+cond|item))

#summary(M1)


#decorrelated

M1 = lmer(data = data, fptarget ~ group * cond + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, fptarget ~ group + cond + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, fptarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))
```

```
M4 = lmer(data = data, fptarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))

summary(M1)


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#need to simplify further, take out cond from subj random
 structure

M1 = lmer(data = data, fpspill ~ group * cond  + (1|subj) +
 (1+cond|item))

M2 = lmer(data = data, fpspill ~ group  + cond + (1|subj) +
 (1+cond|item))

M3 = lmer(data = data, fpspill ~ group  + (1|subj) +
 (1+cond|item))

M4 = lmer(data = data, fpspill ~ cond  + (1|subj) +
 (1+cond|item))


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#RP max model all conds; does not work, decorrelate does not
 work, further simplified without cond anywhere

M1 = lmer(data = data, rptarget ~ group * cond  + (1|subj)  +
 (1|item))

M2 = lmer(data = data, rptarget ~ group  + cond + (1|subj)  +
```

```
(1|item))

M3 = lmer(data = data, rptarget ~ group  + (1|subj) +
(1|item))

M4 = lmer(data = data, rptarget ~ cond  + (1|subj) +
(1|item))


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#RP spill max model all conds; does not work, decorrelate

M1 = lmer(data = data, rpspill ~ group * cond  + (1|subj) +
(0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, rpspill ~ group + cond  + (1|subj) +
(0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, rpspill ~ group  + (1|subj) +
(0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, rpspill ~ cond  + (1|subj) +
(0+cond|subj) + (1+cond|item))


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#RI target max model all conds; does not work, decorrelate,
simplified without cond in subj or item structure

M1 = glmer(data = data, ritarget ~ group * cond  + (1|subj) +
(1|item), family="binomial")
```

```
M2 = glmer(data = data, ritarget ~ group + cond  + (1|subj) +
 (1|item), family="binomial")

M3 = glmer(data = data, ritarget ~ group  + (1|subj) +
 (1|item), family="binomial")

M4 = glmer(data = data, ritarget ~ cond  + (1|subj) +
 (1|item), family="binomial")


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#RI spill max model all conds; does not work, decorrelate,
 simplified without cond in subj or item structure

M1 = glmer(data = data, rispill ~ group * cond  + (1|subj) +
 (1|item), family="binomial")

M2 = glmer(data = data, rispill ~ group + cond  + (1|subj) +
 (1|item), family="binomial")

M3 = glmer(data = data, rispill ~ group  + (1|subj) +
 (1|item), family="binomial")

M4 = glmer(data = data, rispill ~ cond  + (1|subj) + (1|item),
 family="binomial")


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#TT target max model works

M1 = lmer(data = data, tttarget ~ group * cond  +
```

```
(1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, tttarget ~ group + cond  +
(1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, tttarget ~ group  + (1+cond|subj) +
(1+cond|item))

M4 = lmer(data = data, tttarget ~ cond  + (1+cond|subj) +
(1+cond|item))


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#TT spill max model does not work, decorrelate does not work,
take out cond from subj and item structure

M1 = lmer(data = data, ttspill ~ group * cond  + (1|subj) +
(1|item))

M2 = lmer(data = data, ttspill ~ group + cond  + (1|subj) +
(1|item))

M3 = lmer(data = data, ttspill ~ group  + (1|subj) + (1|item))

M4 = lmer(data = data, ttspill ~ cond  + (1|subj) + (1|item))


#interaction?

anova(M1, M2)

#condition?

anova(M2, M3)

#group?

anova(M2, M4)


#comparisons between conditions

contrasts(data$cond) = cbind(MetLit=c(-1,1,0), LitNon=c(0,1,-
```

```
1))
contrasts(data$cond)
summary.lm(aov(data$rptarget~data$cond))

contrasts(data$cond) = cbind(MetLit=c(-1,1,0), LitNon=c(0,1,-
1))
contrasts(data$cond)
summary.lm(aov(data$rpspill~data$cond))

contrasts(data$cond) = cbind(MetLit=c(-1,1,0), LitNon=c(0,1,-
1))
contrasts(data$cond)
summary.lm(aov(data$tttarget~data$cond))

contrasts(data$cond) = cbind(MetLit=c(-1,1,0), LitNon=c(0,1,-
1))
contrasts(data$cond)
summary.lm(aov(data$ttspill~data$cond))

# FP comparisons between conditions for each group
patientdata<-data[data$patient_control == 1,]
head(patientdata)
contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
LitNon=c(0,1,-1))
contrasts(patientdata$cond)
summary.lm(aov(patientdata$fptarget~patientdata$cond))

contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
LitNon=c(0,1,-1))
contrasts(patientdata$cond)
summary.lm(aov(patientdata$fpspill~patientdata$cond))
```

```
controlsdata<-data[data$patient_control == 2,]

head(controlsdata)

contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$fptarget~controlsdata$cond))


contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$fpspill~controlsdata$cond))


# RP comparisons between conditions for each group

patientdata<-data[data$patient_control == 1,]

head(patientdata)

contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$rptarget~patientdata$cond))


contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$rpspill~patientdata$cond))


controlsdata<-data[data$patient_control == 2,]

head(controlsdata)

contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$rptarget~controlsdata$cond))
```

```
contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$rpspill~controlsdata$cond))


# RI comparisons between conditions for each group

patientdata<-data[data$patient_control == 1,]

head(patientdata)

contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$ritarget~patientdata$cond))


contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$rispill~patientdata$cond))


controlsdata<-data[data$patient_control == 2,]

head(controlsdata)

contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$ritarget~controlsdata$cond))


contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$rispill~controlsdata$cond))


# TT comparisons between conditions for each group

patientdata<-data[data$patient_control == 1,]
```

```
head(patientdata)

contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$tttarget~patientdata$cond))


contrasts(patientdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(patientdata$cond)

summary.lm(aov(patientdata$ttspill~patientdata$cond))


controlsdata<-data[data$patient_control == 2,]

head(controlsdata)

contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$tttarget~controlsdata$cond))


contrasts(controlsdata$cond) = cbind(MetLit=c(-1,1,0),
 LitNon=c(0,1,-1))

contrasts(controlsdata$cond)

summary.lm(aov(controlsdata$ttspill~controlsdata$cond))


M1 = lmer(data = data, LogFPtarget ~ group * cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogFPtarget ~ group + cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogFPtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogFPtarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogFPspill ~ group * cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))
```

```
M2 = lmer(data = data, LogFPspill ~ group + cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogFPspill ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogFPspill ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogRPtarget ~ group * cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPtarget ~ group + cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogRPtarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogRPspill ~ group * cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPspill ~ group + cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPspill ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogRPspill ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogTTtarget ~ group * cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTtarget ~ group + cond  + (1|subj)
 + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogTTtarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogTTspill ~ group * cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))
```

```
M2 = lmer(data = data, LogTTspill ~ group + cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTspill ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogTTspill ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M4 = glmer(data = data, ritarget ~ group * cond  + (1|subj) +
 (1|item), family="binomial")

M5 = glmer(data = data, ritarget ~ group + cond  + (1|subj) +
 (1|item), family="binomial")

M6 = glmer(data = data, ritarget ~ group  + (1|subj) +
 (1|item), family="binomial")

M7 = glmer(data = data, ritarget ~ cond  + (1|subj) +
 (1|item), family="binomial")


M4 = glmer(data = data, rispill ~ group * cond  + (1|subj) +
 (1|item), family="binomial")

M5 = glmer(data = data, rispill ~ group + cond  + (1|subj) +
 (1|item), family="binomial")

M6 = glmer(data = data, rispill ~ group  + (1|subj) +
 (1|item), family="binomial")

M7 = glmer(data = data, rispill ~ cond  + (1|subj) + (1|item),
 family="binomial")


M8 = glmer(data = data, LogSPtarget ~ group * cond  + (1|subj)
 + (1|item), family="poisson")

M9 = glmer(data = data, LogSPtarget ~ group + cond  + (1|subj)
 + (0+cond|subj)+ (1+cond|item), family="poisson")

M10 = glmer(data = data, LogSPtarget ~ group + (1|subj) +
 (0+cond|subj)+ (1+cond|item), family="poisson")

M11 = glmer(data = data, LogSPtarget ~ cond  + (1|subj) +
 (0+cond|subj)+ (1+cond|item), family="poisson")


coef(M1)
```

```
#interaction significant?
anova(M1,M2)
anova(M4,M5)
anova(M8,M9)
#cond significant?
anova(M2,M3)
anova(M5,M6)
anova(M9,M10)
#group significant?
anova(M2,M4)
anova(M5,M7)
anova(M9,M11)
contrasts(data$cond) = cbind(LI=c(-1, 1, 0), IP=c(0, 1, -1))
contrasts(data$cond)
summary.lm(aov(data$LogTTspill~data$cond))

#GROUP (when interaction sign)

patientdata<-data[data$patient_control == 1,]
head(patientdata)
contrasts(patientdata$cond) = cbind(LI=c(-1, 1, 0), IP=c(0, 1,
-1))
contrasts(patientdata$cond)
summary.lm(aov(patientdata$LogTTtarget~patientdata$cond))

controldata<-data[data$patient_control == 2,]
head(controldata)
contrasts(controldata$cond) = cbind(LI=c(-1, 1, 0), IP=c(0, 1,
-1))
contrasts(controldata$cond)
summary.lm(aov(controldata$LogTTtarget~controldata$cond))
```

```
#OLD STUFF

#RP all conds


M9 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1+cond|subj) + (1|item), family="poisson")

M10 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1|subj) + (1+cond|item), family="poisson")

M11 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1|subj) + (1|item), family="poisson")

M12 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1|item) + (0+cond|item),
 family="poisson")

M13 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1|subj) + (1|item) + (0+cond|item), family="poisson")

M14 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1|item), family="poisson")


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#TT

M1 = lmer(data = data, tttarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, tttarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, tttarget ~ group + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, tttarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))
```

```
M1 = lmer(data = data, LogTTtarget ~ group * cond  +
(1+cond|subj) + (1+cond+group|item))

M2 = lmer(data = data, LogTTtarget ~ group + cond  +
(1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, LogTTtarget ~ group + (1+cond|subj) +
(1+cond+group|item))

M4 = lmer(data = data, LogTTtarget ~ cond  + (1+cond|subj) +
(1+cond+group|item))


M1 = lmer(data = data, ttspill ~ group * cond  + (1+cond|subj)
+ (1+cond|item))

M2 = lmer(data = data, ttspill ~ group + cond  + (1+cond|subj)
+ (1+cond|item))

M3 = lmer(data = data, ttspill ~ group + (1+cond|subj) +
(1+cond|item))

M4 = lmer(data = data, ttspill ~ cond  + (1+cond|subj) +
(1+cond|item))


M1 = lmer(data = data, LogTTspill ~ group * cond  +
(1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTspill ~ group + cond  +
(1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTspill ~ group + (1+cond|subj) +
(1+cond|item))

M4 = lmer(data = data, LogTTspill ~ cond  + (1+cond|subj) +
(1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#SP
```

```
M1 = glmer(data = data, sptarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M2 = glmer(data = data, sptarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M3 = glmer(data = data, sptarget ~ group  + (1+cond|subj) +
 (1+cond|item), family="poisson")

M4 = glmer(data = data, sptarget ~ cond  + (1+cond|subj) +
 (1+cond|item), family="poisson")

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#log does not work - substitute by hand

M1 = glmer(data = data, LogSPtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M2 = glmer(data = data, LogSPtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item), family="poisson")

M3 = glmer(data = data, LogSPtarget ~ group  + (1+cond|subj) +
 (1+cond|item), family="poisson")

M4 = glmer(data = data, LogSPtarget ~ cond  + (1+cond|subj) +
 (1+cond|item), family="poisson")

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#RI

M1 = lmer(data = data, ritarget ~ group * cond  +
 (1+cond|subj) + (1+cond+group|item))
```

```
M2 = lmer(data = data, ritarget ~ group + cond  +
 (1+cond|subj) + (1+cond+group|item))

M3 = lmer(data = data, ritarget ~ group  + (1+cond|subj) +
 (1+cond+group|item))

M4 = lmer(data = data, ritarget ~ cond  + (1+cond|subj) +
 (1+cond+group|item))

#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#####

#only literal and ironic  Don't use for now


lit_iro<-data[data$condLI == 1,]

head(lit_iro)


tapply(lit_iro$fptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)


M1 = lmer(data = lit_iro, LogTTtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = lit_iro, LogTTtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = lit_iro, LogTTtarget ~ group + (1+cond|subj)
 + (1+cond|item))

M4 = lmer(data = lit_iro, LogTTtarget ~ cond  + (1+cond|subj)
 + (1+cond|item))

#interaction significant?

anova(M1,M2)


#cond significant?
```

```
anova(M2,M3)

#group significant?
anova(M2,M4)

summary(M1)
```

APPENDIX E

Metonymy Eye-tracking stimuli.

In the first version (a) of each item, there is a lexical metonymy. In the second version (b), there is no figurative language involved, it expresses the literal condition. In the third version (c), a logical metonymy is present.

1

a The gentleman read Dickens while waiting for a friend to arrive. She had been running late quite often recently.

b The gentleman spotted Dickens while waiting for a friend to arrive. She had been running late quite often recently.

c The gentleman started Dickens while waiting for a friend to arrive. She had been running late quite often recently.

2

a The bilingual neighbour wanted to translate Anne Frank after he was given the manuscript. He thought it was a very gripping and moving document.

b The bilingual neighbour wanted to warn Anne Frank after he was given the manuscript. He thought it was a very gripping and moving document.

c The bilingual neighbour wanted to begin Anne Frank after he was given the manuscript. He thought it was a very gripping and moving document.

3

a	The music student wished he could conduct Beethoven one day in London. He had always loved that city and couldn't wait to go back there.

b	The music student wished he could visit Beethoven one day in Vienna. He had always loved that city and couldn't wait to go back there.

c	The music student wished he could continue Beethoven one day in Vienna. He had always loved that city and couldn't wait to go back there.

4

a	The philanthropist published T. S. Eliot just before the beginning of the holidays. He has planned to go to the seaside for a well-deserved rest.

b	The philanthropist welcomed T.S. Eliot just before the beginning of the holidays. He has planned to go to the seaside for a well-deserved rest.

c	The philanthropist finished T.S. Eliot just before the beginning of the holidays. He has planned to go to the seaside for a well-deserved rest.

5

a	In order to relax, he used to play Bob Marley on his stereo at home. He lived in a beautiful villa in the hills of Los Angeles.

b	In order to relax, he used to paint Bob Marley on his easel at home. He lived in a beautiful villa in the hills of Los Angeles.

c	In order to relax, he used to enjoy Bob Marley on his stereo at home. He lived in a beautiful villa in the hills of Los Angeles.

6

a	The educated slave quoted Aristotle at the festival in Athens. The festival was normally held during the spring.

b	The educated slave greeted Aristotle at the festival in Athens. The festival was normally held during the spring.

c The educated slave began Aristotle at the festival in Athens. The festival was normally held during the spring.

7

a The well-read housewife neutral Agatha Christie in the town by the seaside. It was a very nice and warm place, especially in the summer.

b The well-read housewife befriended Agatha Christie in the town by the seaside. It was a very nice and warm place, especially in the summer.

c The well-read housewife enjoyed Agatha Christie in the town by the seaside. It was a very nice and warm place, especially in the summer.

8

a The record producer decided to re-sample Rihanna without first obtaining all the necessary permissions. The lawsuit could cost him hundreds of thousands.

b The record producer decided to photograph Rihanna without first obtaining all the necessary permissions. The lawsuit could cost him hundreds of thousands.

c The record producer decided to discontinue Rihanna without first obtaining all the necessary permissions. The lawsuit could cost him hundreds of thousands.

9.

a The editor published Wittgenstein just before resigning from the firm. He had decided to set up his own company.

b The editor contacted Wittgenstein just before resigning from the firm. He had decided to set up his own company.

c The editor mastered Wittgenstein just before resigning from the firm. He had decided to set up his own company.

10

a According to music industry rumours, they had re-released Elvis Presley in the hope of selling millions of records to a new and younger public. However, in the end the sales were quite disappointing.

b According to music industry rumours, they had interviewed Elvis Presley in the hope of selling millions of records to a new and younger public. However, in the end the sales were quite disappointing.

c According to music industry rumours, they had resumed Elvis Presley in the hope of selling millions of records to a new and younger public. However, in the end the sales were quite disappointing.

11

a The eccentric physics student corroborated Einstein and then decided to develop his own theory. He sent his best research to the journal Nature, but it got rejected.

b The eccentric physics student annoyed Einstein and then decided to develop his own theory. He sent his best research to the journal Nature, but it got rejected.

c The eccentric physics student mastered Einstein and then decided to develop his own theory. He sent his best research to the journal Nature, but it got rejected.

12

a In the show, the band member wanted to play Frank Sinatra rather than anyone else in order to impress his family. Sinatra was well appreciated by everyone in his family.

b In the show, the band member wanted to meet Frank Sinatra rather than anyone else in order to impress his family. Sinatra was well appreciated by everyone in his family.

c In the show, the band member wanted to practice Frank Sinatra rather than anyone else in order to impress his family. Sinatra was well appreciated by everyone in his family.

13

a It’s a fact that the company that decided to launch J.K. Rowling took a gamble that paid off tremendously. They’re now the second largest publishing house in the UK.

b It’s a fact that the company that decided to phone J.K. Rowling took a gamble that paid off tremendously. They’re now the second largest publishing house in the UK.

c It’s a fact that the company that decided to delay J.K. Rowling took a gamble that paid off tremendously. They’re now the second largest publishing house in the UK.

14

a The romantic teenager must have re-read Jane Austen at least five times in two years. She has always had a dreamy streak in her.

b The romantic teenager must have contacted Jane Austen at least five times in two years. She has always had a dreamy streak in her.

c The romantic teenager must have re-started Jane Austen at least five times in two years. She has always had a dreamy streak in her.

15

a As an undergraduate lecturer, Jonathan tried to explain Freud but he was not very succesful. The students liked psycho-analytical theories even though they are often not experimentally supported.

b As an undergraduate lecturer, Jonathan tried to invite Freud but he was not very succesful. The students liked psycho-analytical theories even though they are often not experimentally supported.

c As an undergraduate lecturer, Jonathan tried to enjoy Freud but he was not very succesful. The students liked psycho-analytical theories even though they are often not experimentally supported.

16

a The radio station announced that they will play Lady Gaga every time someone donates a tenner to their chosen good cause. They were raising money for the Acorns charity.

b The radio station announced that they will hear Lady Gaga every time someone donates a tenner to their chosen good cause. They were raising money for the Acorns charity.

c The radio station announced that they will begin Lady Gaga every time someone donates a tenner to their chosen good cause. They were raising money for the Acorns charity.

17

a At the end of the contest, the young candidate sang Justin Bieber in a mockish way, but he failed miserably. He was quickly voted off.

b At the end of the contest, the young candidate imitated Justin Bieber in a mockish way, but he failed miserably. He was quickly voted off.

c At the end of the contest, the young candidate concluded Justin Bieber in a mockish way, but he failed miserably. He was quickly voted off.

18

a The scientist translated Stephen Hawking before going back to live in Lisbon. He appreciated the weather there and was happy with his decision.

b The scientist wrote Stephen Hawking before going back to live in Lisbon. He appreciated the weather there and was happy with his decision.

c The scientist finished Stephen Hawing before going back to live in Lisbon. He appreciated the weather there and was happy with his decision.

19

a The student re-read Sartre while living in the south of France. He found the philosopher a bit boring though.

b The student invited Sartre while living in the south of France. He found the philosopher a bit boring though.

c The student continued Sartre while living in the south of France. He found the philosopher a bit boring though.

20

a The old musician was elated when asked to conduct Mozart in front of the king’s entourage. The concert was to take place in the summer palace.

b The old musician was elated when asked to honour Mozart in front of the king’s entourage. The concert was to take place in the summer palace.

c The old musician was elated when asked to practice Mozart in front of the king’s entourage. The concert was to take place in the summer palace.

21

a The unknown painter was asked to duplicate Michelangelo but he refused the request as it went against everything he believed in. Years later, he was working as a shoe maker.

b The unknown painter was asked to support Michelangelo but he refused the request as it went against everything he believed in. Years later, he was working as a shoe maker.

c The unknown painter was asked to complete Michelangelo but he refused the request as it went against everything he believed in. Years later, he was working as a shoe maker.

22

a Astronomers in the eighteenth century developed Newton in a number of different ways. But they never received the same name recognition.

b Astronomers in the eighteenth century helped Newton in a number of different ways. But they never received the same name recognition.

c Astronomers in the eighteenth century completed Newton in a number of different ways. But they never received the same name recognition.

23

a The company decided to no longer distribute Pavarotti because they noticed that sales had fallen sharply in the last few years. They were now at the point of going bankrupt.

b The company decided to no longer employ Pavarotti because they noticed that sales had fallen sharply in the last few years. They were now at the point of going bankrupt.

c The company decided to no longer delay Pavarotti because they noticed that sales had fallen sharply in the last few years. They were now at the point of going bankrupt.

24

a Because the insurance was too high, they decided not to exhibit Picasso but rather go for some up and coming young talent. An artist from the Lake District had caught their eyes.

b Because the insurance was too high, they decided not to invite Picasso but rather go for some up and coming young talent. An artist from the Lake District had caught their eyes.

c Because the insurance was too high, they decided not to commence Picasso but rather go for some up and coming young talent. An artist from the Lake District had caught their eyes.

25

a The publishers made the decision to adapt Roald Dahl because they wanted their books to contain nothing too cynical. But by doing so, they ruined most of the good bits.

b The publishers made the decision to call Roald Dahl because they wanted their books to contain nothing too cynical. But by doing so, they ruined most of the good bits.

c The publishers made the decision to conclude Roald Dahl because they wanted their books to contain nothing too cynical. But by doing so, they ruined most of the good bits.

26

a Even his favourite actor found it hard to recite Shakespeare in front of an audience. People seemed to be having fun though.

b Even his favourite actor found it hard to oppose Shakespeare in front of an audience. People seemed to be having fun though.

c Even his favourite actor found it hard to start Shakespeare in front of an audience. People seemed to be having fun though.

27

a The young physicist could always simplify Einstein if he wanted to. At the moment, he was not entirely sure of his propositions and admitted that some of the ideas are quite challenging.

b The young physicist could always phone Einstein if he wanted to. At the moment, he was not entirely sure of his propositions and admitted that some of the ideas are quite challenging.

c The young physicist could always master Einstein if he wanted to. At the moment, he was not entirely sure of his propositions and admitted that some of the ideas are quite challenging.

28

a Outside the theatre, the muscled man performed Tom Jones in an absent-minded way. He was thinking about the girl he was going to see that evening.

b Outside the theatre, the muscled man protected Tom Jones in an absent-minded way. He was thinking about the girl he was going to see that evening.

c Outside the theatre, the muscled man attempted Tom Jones in an absent-minded way. He was thinking about the girl he was going to see that evening.

29

a On the talent show, the young man performed Eminem in a very convincing way. He said Eminem was the best when it comes to rap music.

b On the talent show, the young man praised Eminem in a very convincing way. He said Eminem was the best when it comes to rap music.

c On the talent show, the young man attempted Eminem in a very convincing way. He said Eminem was the best when it comes to rap music.

30

a The archbishop decided to display da Vinci at some other time in the near future. However, he wouldn’t say whether that was next year or not.

b The archbishop decided to contact da Vinci at some other time in the near future. However, he wouldn’t say whether that was next year or not.

c The archbishop decided to discontinue da Vinci some other time in the near future. However, he wouldn’t say whether that was next year or not.

31

a The gallery owner who studied Art and Design continued to forge Warhol for quite a few years. But in the end he realised it was a mistake.

b The gallery owner who studied Art and Design continued to harass Warhol for quite a few years. But in the end he realised it was a mistake.

c The gallery owner who studied Art and Design continued to postpone Warhol for quite a few years. But in the end he realised it was a mistake.

32

a The book company's decision to print J.R.R. Tolkien turned out to be a lucrative move. Both the company and the author made a tidy sum out of the arrangement.

b The book company's decision to hire J.R.R. Tolkien turned out to be a lucrative move. Both the company and the author made a tidy sum out of the arrangement.

c The book company's decision to continue J.R.R. Tolkien turned out to be a lucrative move. Both the company and the author made a tidy sum out of the arrangement.

33.

a The local cinema decided to screen Hitchcock after several people requested it. Everyone likes a good psychological thriller.

b The local cinema decided to award Hitchcock after several people requested it. Everyone likes a good psychological thriller.

c The local cinema decided to resume Hitchcock after several people requested it. Everyone likes a good psychological thriller.

Table 36 - Percentage of errors in the sentence interpretation task – Metonymy Experiment - patient group

Participant	*Percentage of Errors in Literal Processing*	*Percentage of Errors in Lexical Metonymy Processing*	*Percentage of Errors in Logical Metonymy Processing*
1	50	0	0
2	20	20	17
3	36	0	30
4	20	0	42
5	9	17	50
6	36	0	43
7	18	0	50
8	30	10	33
9	9	0	50
10	27	0	7
11	9	0	40
12	0	10	8
13	18	0	45
14	20	0	33
15	20	0	25
16	10	10	17
17	30	10	25
18	4.5	0	25
19	27	0	21.5
20	18	0	20
21	0	0	7
22	32	0	29
23	73	11	64
24	9	0	21.5
25	27	25	60
Mean(SD)	*22.1(7.42)*	*4.52(16.12)*	*30.52(17.08)*

Table 37 - Percentage of errors in the sentence interpretation task - Metonymy Experiment – control group

Participant	*Percentage of Errors in Literal Processing*	*Percentage of Errors in Lexical Metonymy Processing*	*Percentage of Errors in Logical Metonymy Processing*
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	9	8.3	40
15	0	0	0
16	0	0	0
17	0	0	0
18	0	0	0
19	0	0	0
20	0	0	0
21	0	0	0
Mean(SD)	*1.98(1.98)*	*1.81(1.81)*	*8.72(8.72)*

```
#read in file metonymy_final.csv

data = read.csv(file.choose(), header = T)
head(data)

library(lme4)
library(languageR)
library(lmerTest)
library(MASS)
library(cAIC4)
library(ggplot2)
library(plyr)

citation()

data$subj <- factor(data$subj)
data$item <- factor(data$item)
data$group <- factor(ifelse(data$patient_control == 1,
 "PwS", "Control"))
data$cond <- factor(data$cond)
data$LogFPtarget<-
 as.numeric(as.character(data$LogFPtarget),na.rm = TRUE)
data$LogFPspill<-
 as.numeric(as.character(data$LogFPspill),na.rm = TRUE)
data$LogRPtarget<-
 as.numeric(as.character(data$LogRPtarget),na.rm = TRUE)
data$LogRPspill<-
 as.numeric(as.character(data$LogRPspill),na.rm = TRUE)
data$LogTTtarget<-
 as.numeric(as.character(data$LogTTtarget),na.rm = TRUE)
```

```
data$LogTTspill<-
 as.numeric(as.character(data$LogTTspill),na.rm = TRUE)


data$fptarget <- as.numeric(as.character(data$fptarget))

data$rptarget <- as.numeric(as.character(data$rptarget))

data$rpspill <- as.numeric(as.character(data$rpspill))

data$tttarget <- as.numeric(as.character(data$tttarget))

data$ttspill <- as.numeric(as.character(data$ttspill))

data$ritarget <- as.numeric(as.character(data$ritarget))

data$rispill <- as.numeric(as.character(data$rispill))


tapply(data$fptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$fptarget, list(data$cond), na.rm = TRUE, mean)

tapply(data$fpspill, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$fpspill, list(data$cond), na.rm = TRUE, mean)

tapply(data$rptarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$rptarget, list(data$cond), na.rm = TRUE, mean)

tapply(data$rpspill, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$rpspill, list(data$cond), na.rm = TRUE, mean)

tapply(data$ritarget, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$ritarget, list(data$cond), na.rm = TRUE, mean)

tapply(data$rispill, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$rispill, list(data$cond), na.rm = TRUE, mean)

tapply(data$tttarget, list(data$group, data$cond), na.rm =
 TRUE, mean)
```

```
tapply(data$tttarget, list(data$cond), na.rm = TRUE, mean)

tapply(data$ttspill, list(data$group, data$cond), na.rm =
 TRUE, mean)

tapply(data$ttspill, list(data$cond), na.rm = TRUE, mean)


Myplot<-ggplot(data,aes(x=cond,y=LogFPtarget))+geom_point()

Myplot<-Myplot + geom_smooth(method="lm")

Myplot+ geom_point(aes(colour = factor(group)), size=2)


#First model to try - maximal

#First pass TARGET

M1 = lmer(data = data, LogFPtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogFPtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogFPtarget ~ group + (1+cond|subj)
 + (1+cond|item))

M4 = lmer(data = data, LogFPtarget ~ cond  + (1+cond|subj)
 + (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#First pass SPILL

M1 = lmer(data = data, LogFPspill ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogFPspill ~ group + cond  +
```

```
(1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogFPspill ~ group + (1+cond|subj) +
(1+cond|item))

M4 = lmer(data = data, LogFPspill ~ cond  + (1+cond|subj) +
(1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#RegPath TARGET

M1 = lmer(data = data, LogRPtarget ~ group * cond  +
(1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPtarget ~ group + cond  +
(1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPtarget ~ group + (1+cond|subj)
+ (1+cond|item))

M4 = lmer(data = data, LogRPtarget ~ cond  + (1+cond|subj)
+ (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#RegPath SPILL
```

```
M1 = lmer(data = data, LogRPspill ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPspill ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPspill ~ group + (1+cond|subj) +
 (1+cond|item))

M4 = lmer(data = data, LogRPspill ~ cond  + (1+cond|subj) +
 (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#TOTAL TIME TARGET

M1 = lmer(data = data, LogTTtarget ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTtarget ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTtarget ~ group + (1+cond|subj)
 + (1+cond|item))

M4 = lmer(data = data, LogTTtarget ~ cond  + (1+cond|subj)
 + (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?
```

```
anova(M2,M4)


#TOTAL TIME SPILL

M1 = lmer(data = data, LogTTspill ~ group * cond  +
 (1+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTspill ~ group + cond  +
 (1+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTspill ~ group + (1+cond|subj) +
 (1+cond|item))

M4 = lmer(data = data, LogTTspill ~ cond  + (1+cond|subj) +
 (1+cond|item))


#interaction significant?

anova(M1,M2)

#cond significant?

anova(M2,M3)

#group significant?

anova(M2,M4)


#REGS IN TARGET

M1 = glmer(data = data, ritarget ~ group * cond  + (1|subj)
 + (1|item), family="binomial")

M2 = glmer(data = data, ritarget ~ group + cond  + (1|subj)
 + (1|item), family="binomial")

M3 = glmer(data = data, ritarget ~ group  + (1|subj) +
 (1|item), family="binomial")

M4 = glmer(data = data, ritarget ~ cond  + (1|subj) +
 (1|item), family="binomial")


#interaction significant?

anova(M1,M2)
```

```
#cond significant?
anova(M2,M3)
#group significant?
anova(M2,M4)


#REGS IN SPILL
M1 = glmer(data = data, rispill ~ group * cond  + (1|subj)
 + (1|item), family="binomial")
M2 = glmer(data = data, rispill ~ group + cond  + (1|subj)
 + (1|item), family="binomial")
M3 = glmer(data = data, rispill ~ group  + (1|subj) +
 (1|item), family="binomial")
M4 = glmer(data = data, rispill ~ cond  + (1|subj) +
 (1|item), family="binomial")


#interaction significant?
anova(M1,M2)
#cond significant?
anova(M2,M3)
#group significant?
anova(M2,M4)


M1 = lmer(data = data, LogFPtarget ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))
M2 = lmer(data = data, LogFPtarget ~ group + cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))
M3 = lmer(data = data, LogFPtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))
M4 = lmer(data = data, LogFPtarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))
```

```
M1 = lmer(data = data, LogFPspill ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogFPspill ~ group + cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogFPspill ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogFPspill ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogRPtarget ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPtarget ~ group + cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogRPtarget ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogRPspill ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogRPspill ~ group + cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogRPspill ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogRPspill ~ cond  + (1|subj) +
 (0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogTTtarget ~ group * cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTtarget ~ group + cond  +
 (1|subj) + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTtarget ~ group + (1|subj) +
 (0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogTTtarget ~ cond  + (1|subj) +
```

```
(0+cond|subj) + (1+cond|item))


M1 = lmer(data = data, LogTTspill ~ group * cond  +
(1|subj) + (0+cond|subj) + (1+cond|item))

M2 = lmer(data = data, LogTTspill ~ group + cond  +
(1|subj) + (0+cond|subj) + (1+cond|item))

M3 = lmer(data = data, LogTTspill ~ group + (1|subj) +
(0+cond|subj) + (1+cond|item))

M4 = lmer(data = data, LogTTspill ~ cond  + (1|subj) +
(0+cond|subj) + (1+cond|item))


M4 = glmer(data = data, ritarget ~ group * cond  + (1|subj)
+ (1|item), family="binomial")

M5 = glmer(data = data, ritarget ~ group + cond  + (1|subj)
+ (1|item), family="binomial")

M6 = glmer(data = data, ritarget ~ group  + (1|subj) +
(1|item), family="binomial")

M7 = glmer(data = data, ritarget ~ cond  + (1|subj) +
(1|item), family="binomial")


M4 = glmer(data = data, rispill ~ group * cond  + (1|subj)
+ (1|item), family="binomial")

M5 = glmer(data = data, rispill ~ group + cond  + (1|subj)
+ (1|item), family="binomial")

M6 = glmer(data = data, rispill ~ group  + (1|subj) +
(1|item), family="binomial")

M7 = glmer(data = data, rispill ~ cond  + (1|subj) +
(1|item), family="binomial")


M8 = glmer(data = data, LogSPtarget ~ group * cond  +
(1|subj) + (1|item), family="poisson")

M9 = glmer(data = data, LogSPtarget ~ group + cond  +
(1|subj) + (0+cond|subj)+ (1+cond|item), family="poisson")
```

```
M10 = glmer(data = data, LogSPtarget ~ group + (1|subj) +
 (0+cond|subj)+ (1+cond|item), family="poisson")

M11 = glmer(data = data, LogSPtarget ~ cond  + (1|subj) +
 (0+cond|subj)+ (1+cond|item), family="poisson")
```