The Effects of Social Context and Perspective on Language Processing: Evidence from Autism Spectrum Disorder

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Declaration

The research presented in this thesis was conducted at the School of Psychology, University of Kent, whilst the author was a full-time postgraduate student, supported by a Leverhulme Trust PhD studentship, under the supervision of Professor Heather Ferguson. Chapters 3, 4, and 5 of this thesis have now been published, however at the time of submission chapters 4 and 5 were under review at different journals. You can find the published versions online. The data reported in Chapters 2, 3, 4 and 5 has been presented at numerous conferences.

Peer-reviewed Journal articles:

- Barzy, M., Black, J., Williams, D., & Ferguson, H. J. (2020). Autistic adults anticipate and integrate meaning based on the speaker's voice: Evidence from eye-tracking and event-related potentials. *Journal of Experimental Psychology: General*, *149*(6), 1097.
- Barzy, M., Filik, R., Williams, D., & Ferguson, H. J. (2020). Emotional Processing of Ironic Versus Literal Criticism in Autistic and Nonautistic Adults: Evidence From Eye-Tracking. *Autism Research*, *13*(4), 563-578.
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- Barzy, M., Black, J., Williams, D., & Ferguson, H.J. (Aug 2018). Anticipation and integration processes of speaker and meaning in individuals with and without autism: evidence from eye-tracking and ERPs. Poster presented at Embodied and Situated Language Processing (ESLP) conference, University of Lancaster, UK.

- Barzy, M., Black, J., Williams, D., & Ferguson, H.J. (May 2018). The Effect of Personal Pronouns on Perspective and Language Comprehension in Autism: An Eye-Tracking Study. Poster presented at the international meeting of Psychonomic Society, Amsterdam, Netherlands.

- Barzy, M., Black, J., Williams, D., & Ferguson, H.J. (2018). The Effect of Personal Pronouns on Perspective and Language Comprehension in Autism: An Eye-Tracking Study. Poster presented at the Experimental Psychology Society meeting, London, UK.

Abstract

This thesis aimed to provide new insights into the role of perspective and non-linguistic context in language processing among autistic and typically developing (TD) adults. The mental simulation account and the one-step model state that language is mentally simulated and interpreted in context, suggesting that these processes are activated online while linguistic input is processed. Little is known of whether the same processes are activated in autism. In seven experiments (four were fully pre-registered), I used offline and online measures (e.g. EEG, eye-tracking) to investigate how social factors, such as the perspective, speaker's voice, emotional states of the characters, and topic of conversation influence language comprehension in both lab and real-life settings, in autism and TD adults. Based on the weak central coherence (WCC), and the complex information processing disorder (CIPD) theories, it was expected that autistic adults would struggle to integrate the social context with language, or at least show some subtle delays in the time-course of these anticipation/integration processes. First, I failed to find the same effect as previous findings, showing enhanced processing for personalized language, suggesting that this process is dependent on individual preferences in perspective-taking and task demands. Furthermore, I found that contrary to the WCC, autistic individuals had an intact ability to integrate social context online, while extracting the meaning from language. There were subtle differences in the time-course and strength of these processes between autistic and TD adults under high cognitive load. Findings are in line with CIPD hypothesis, showing that online language processes are disrupted as task demands increase, which consequently affect the quality of their social interactions. Future research

should further investigate how these subtle differences impact social communication abilities in everyday life in autism.

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Chapter 1: Introduction

1.1. Overview

The main aim of this thesis is to explore how individuals extract meaning from linguistic input, specifically whether these processes are comparable in autistic and non-autistic people[1]. This thesis will study this question from both cognitive and pragmatic perspectives by focusing on three related questions: 1) how does representing others' mental states and perspective influence language processing and real-life social interaction in autism, 2) whether and at which stage contextual factors, such as social stereotypes, voice of speaker and emotions etc. are integrated with linguistic input and whether the time-course of these processes are comparable in autistic and typically developing (TD) individuals, and finally 3) do autistic and non-autistic people mentally simulate text and its different dimensions while processing language? I have applied widely-used psycholinguistic methods, including event related potentials (ERPs), eye-tracking and behavioural measures to fulfil these goals. Since, most of the studies in the area are lab-based studies where language is highly structured, I also employed mobile eye-tracking to investigate this topic in ecologically valid real-life social interactions.

In this first chapter, I will introduce some of the most prominent cognitive theories of language processing, including accounts that suggest mental simulations of language are important for extracting meaning. Then, I will consider how pragmatic abilities help us to extract meaning, focusing on the role of context in language comprehension and defining some of these contextual factors. I will also describe how real-time measures can be employed to study the effect of context in

[1] There have been recent debates about the most appropriate terminology to use to describe autism, and throughout this thesis I have adopted the identity-first language preferred by autistic adults who took part in the study by Kenny, Hattersley, Molins, Buckley, Povey, and Pellicano (2016).

language processing, and explain why studying these top-down processes (i.e. pragmatics and mental simulations of language) is important to get a more coherent understanding of language processing. Next, I will introduce autism as a neurodevelopmental disorder that is characterised by specific difficulties with social communication. I will give an overview of cognitive and social theories of autism, and will discuss evidence to show the nature of language atypicalities in autism. I will explain these theories by focusing on the difficulties these individuals experience while interpreting the language in context and building mental models of text online.

1.2. Theories of language processing

Numerous theories have been put forward to explain how we extract meaning from language. Below, I will discuss some of the most prominent ones, including schema theory, situation models, and the embodied view of language processing.

1.2.1. Schema theory

The schema theory of language processing, first proposed by Bartlett (1932), emphasises on the role of prior knowledge and experience in understanding language (Kintsch, 1974; Schank & Abelson, 1977). This theory suggests that it is not the words that necessarily carry the message, but in fact this process is completed through mapping the words onto our previous knowledge. This theory claims that our previous knowledge is stored as schemas in memory, and the comprehension process requires the activation of these schemas in order to interpret the language. It has been suggested that these schemas also contain information regarding the relationship between different elements of our previous knowledge (An, 2013). This theory considers these schemas as building blocks that assist us in constructing models of the linguistic input.

However, this theory has been criticised by many scholars because of the lack of any detailed explanation regarding the nature of these blocks, how they are organised in the brain, or how they are represented in different situations (Logan, 1997; Nassaji, 2002; Paivio, 2007). For example, Nassaji (2002) believes little attention is paid to the way that these schemas are constructed or activated in the first place. For example, based on this theory readers should not be able to understand text before activating the relevant schemas, however, Nassaji has questioned how individuals know which schemas to activate if they have not understood the text.

1.2.2. Situation model theory

Despite the fact that comprehension is a cognitively demanding task, people do it almost effortlessly. It has been suggested that while comprehending language individuals focus on extracting the meaning from the text by and mentally representing the situations that are describedwithin the text, rather than representing the text itself or its language structure (Garnham, 1981). Hence, sentences are not solely abstract linguistic structures but they are sources of information, extracted in terms of mental models that are absorbed by the readers. This claim is the basis of developing the "mental model" or "situation model theory" of language processing (Bransford, Barclay, & Franks, 1972; Glenberg, Meyer, & Lindem, 1987; Zwaan & Radvansky, 1998).

The situation model theory posits that individuals process text by representing the situations rather than the text itself (Zwaan, 2003). Hence, an individual's representation of the text not only involves the content of the story, but also the construction of the situations itself (e.g. how the environment in the story looks or the characters' intentions, goals etc.; Zwaan & Radvansky, 1998; Louwerse & Jeuniaux, 2008). It is believed that individuals' pragmatic abilities, their world knowledge, and the actual text itself help them to construct the mental models (Zwaan & Radvansky, 1998).

Zwaan further developed this theory by proposing the event-indexing model, in which he claims that individuals comprehend narratives by constructing mental models of events/actions that are happening in the text (Zwaan, 1999). He suggested that the models constantly get updated as readers go through the text. He believes that situation models are built based on five specific dimensions: time, space, causation, intentionality, and protagonist. Zwaan believes that the most important factors for building situation models are the events and intentional actions of the characters in the story (Zwaan, 2016). He describes these as building blocks, necessary for the comprehension process (i.e. the representation of text is action based).

1.2.3. The embodied view of language comprehension

Simulation accounts of language processing propose that constructing a mental representation of an object requires activating a representation of that object and its features from memory (e.g. "how would it be like to interact with that object or the object's sound, shape, tactile features etc."). Thus, while reading a text, the concepts within the text are mentally represented from different states of mind including, motor, perceptual and affective states. The simulation approach has been the centre of attention in the area of language processing but naturally, it has been approached in different ways. The embodied view of language processing has been built on the same idea.

The embodied view suggests that there are close ties between higher cognitive functions, such as language and our sensorimotor experiences (Barsalou, 2008; Glenberg & Kaschak 2002; Zwaan, 2009). They claim that language is not an abstract concept or independent of other cognitive functions. On the contrary, it is created based on our daily life experiences and it interacts with different domains, including our bodies. For example, in our daily life we use idioms, such as “we are in this together, side by side” which shows the embodied nature of language. Here we used our bodily experience to make a conceptual meaning (Nguyen, 2009).

Criticism of the embodied view mostly comes from scholars who take an amodal symbolic approach to language processing. The amodal symbolic theorists claim that symbols derive their meaning from other amodal or abstract symbols or through their associations with them (Landauer, & Dumais, 1997). These symbols include colours, distance, emotions, properties, etc. For example, from an amodal view individuals associate the flower “rose” with the colour “red”, so red is the symbolic value of the flower rose (Louwerse & Jeuniaux, 2008). Although the amodal view could potentially capture the relations between entities, it lacks the ability to create a flexible model that is adjustable in different situations. For example, imagine the following sentences:

(1a) The ranger saw the eagle in the sky.

(1b) The ranger saw the eagle in the nest.

Importantly, the shape of an eagle differs significantly in the sky (wings outstretched) and in its nest (wings folded). From an embodied view, the reader would create two different mental models while reading the above sentences, however the amodal view would struggle to capture this difference (Zwaan, 2003).

Several lines of experimental evidence have been put forward in support of the embodied view of language processing. For example, numerous studies have demonstrated that verbally describing a directional movement facilitates the execution of those actions. This phenomenon, known as the "action-sentence compatibility effect", was first proposed by Glenberg and Kaschak (2002). In their study, they asked participants to indicate whether sentences made sense or not. They were required to respond using buttons, which were positioned so that they either had to move their hands away from or towards their bodies. It was shown that participants were faster responding when the direction of the movement in the sentence was compatible with the direction of their hand action (e.g. "opening the drawer" was processed faster when they had to move their hands towards their bodies rather than away from it). Further evidence to support the embodied view, comes from a study which showed that high embodiment verbs, such as "put" or "produce", are better recalled than low embodiment verbs, such as "absorb" or "belong" (Sidhu & Pexman, 2016).

Neuroimaging evidence also shows that the primary motor cortex areas are activated when we process words that are associated with different actions (Hauk, Johnsrude, & Pulvermüller, 2004; Pulvermüller, 2005; Pulvermüller, Härle, M., & Hummel, 2001). Plus, individuals' hemodynamic activity changes depending on the word that they are comprehending. For example, an fMRI study showed a greater level of activation in the bilateral inferior parietal lobule, when individuals processed words that were associated with specific motor actions, such as wiping, than those with a general motor action, such as cleaning (Van Dam, Rueschemeyer, &

Bekkering, 2010). These findings fit with the embodied view's claim that while individuals process action words, the areas in the brain that are associated with executing those actions become activated (Jirak, Menz, Buccino, Borghi, & Binkofski, 2010).

However, results from studies that have used the sentence-picture verification paradigm (SPV) are more mixed. In this paradigm, participants are first presented with a sentence, which describes a feature of an object (e.g. shape, colour, etc.), then they are presented with a picture of that object, in which the feature either matches or mismatches the linguistic description. Participant's task is simply to respond to whether the object in the picture was mentioned in the sentence or not. For example, first, they could read about an egg in a pan, and then they would be presented with either a picture of a whole egg (mismatching shape) or a cracked egg outside its shell (match). It has been shown that participants are faster responding to the stimulus, when the object in the picture matched the shape implied in the preceding sentence (Stanfield, & Zwaan, 2001; Zwaan, & Madden, 2005; Zwaan, Stanfield, & Yaxley, 2002). However, some studies have failed to replicate the original findings or have found relatively small effect sizes (Yaxley, & Zwaan, 2007; Zwaan, & Pecher, 2012; de Koning, Wassenburg, Bos, & van der Schoot, 2017; Koster, Cadierno, & Chiarandini, 2018). Some researchers have suggested that the failure to replicate these findings is associated with whether the entity that was manipulated was important for comprehending the story or not. For example, the shape of an object may not necessarily matter to the action that a protagonist is performing, their goals etc. and in these situations, people may not necessarily mentally simulate that particular entity while processing language (Zwaan & Pecher, 2012).

In general, the embodied view and situation model theory of language processing shows that inferring the sentence's meaning goes above and beyond processing the linguistic input. We build online models of what is happening in the story when we process language. Language is mentally simulated, and is grounded in cognition and action. However, simulating the language is not the only factor that assists us to process language, but language is interpreted based on broader context, such as our audience, the situation we are in etc. These theories fail to accommodate this broader context, which is closely linked to the language comprehension process. Both mental simulation and contextual factors (i.e. pragmatics) are associated with top-down language processing, allowing the language user to interpret language online using the broader context (Cosentino, 2014). For example, during a conversation we are required to represent the mental states of others and to be able to do this we need to understand their intentions which is mediated through embodying their actions (Iacoboni, Molnar-Szakacs, Gallese, Buccino, Mazziotta, & Rizzolatti, 2005). The next section of this chapter reviews recent research into pragmatic language comprehension, and how the wider context influences understanding and meaning.

1.3. Pragmatic Language

Pragmatics is the ability to comprehend language within the context it is presented (Thomas, 2014). Pragmatics has been defined as the rules of language in use. Hence, the study of pragmatics is not only concerned with the way that language is structured but also how we, as human beings, apply it in everyday life to meet our goals (Perkins, 2010). For example, through pragmatics abilities, we figure the meaning that a speaker is intending to send (Levinson, 2004). Imagine a situation in which you have written an essay at the last minute to meet a deadline. The teacher asks “do you call this an essay?” This is where your pragmatics abilities help you understand the message that the speaker is trying to send is a negative message (i.e. this work is not good enough), and not a question (i.e. whether you think this is an essay). This example shows that sometimes there is a fundamental difference between the explicit and the implicit message that a speaker is trying to send.

Thus, to interpret language we should go beyond semantics or what is presented in the text and that’s why modern linguists study the components of language, including phonetics, phonology, syntax, semantics and pragmatics, as complementary subjects (Collins, 2013). Furthermore, traditionally, within the area of pragmatics much attention was paid to the linguistic aspects of pragmatics, such as propositions, verbosity etc. but recently there is a growing body of literature that recognises pragmatics beyond this traditional view by including factors, such as gestures, speaker’s intentions, body language etc. (Collins, 2013; Wharton, 2009). In the next section, I will introduce different types of contextual factors that have been studied within the area of pragmatics.

1.3.1. Language comprehension and contextual factors

We use language to share ideas, thoughts and feelings with one another. The type of language we choose to transfer information varies significantly from one context to another (Dietrich & Graumann, 2014). For example, the way we talk to a child significantly differs from the way we talk to our adult friends. These contextual factors have been divided to four different categories, including 1) social context is defined as the social relationship between the characters that are interacting (e.g. “the way you interact with your teacher is completely different to the way you interact with your friend"), 2) physical context refers to the factors that are environmentally based, such as where and when the language is used, the objects that are around, what actions are carried out etc. (e.g. "in a library vs. at a party"), 3) linguistic context refers to what has been previously mentioned in the conversation (i.e. former utterances discussed), and finally 4) the epistemic context refers to the prior knowledge of the speaker and the listener about the world or their shared background knowledge (e.g. "while discussing a topic with your friend, you modulate your language based on how much they know about that particular topic"). The physical, epistemic and social context are considered extra-linguistic contextual factors (Braber, Cummings, & Morrish, 2015).

Furthermore, recent developments in the area of pragmatics, especially using sensitive measures to examine comprehension online (i.e. in real-time), have led to a renewed interest in paralinguistic contextual factors. These incidental factors accompany speech and assist us to modify, modulate and clarify speech. Some of these paralinguistic factors include body language, facial expression, emotional processing, eye gaze, tone of voice etc. (Parola, Gabbatore, Bosco, Cossa, Gindri, & Sacco, 2015).

It is important to mention that in this thesis the phrase 'language in context' refers to both building mental models of events to interpret language, and representing/modelling others' mental states to facilitate language comprehension.

1.3.2. Using online measures to study context in language

In the history of psycholinguists, there has been a long-standing debate concerning the relationship between syntactic/semantic processing of the linguistic input, processing the context in which it is happening, and higher cognitive functions

(Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). Whilst some believe that there are two different mental processes involved in language processing (first processing the linguistic input in a bottom-up fashion and second combining the world knowledge with discourse content), others view these processes as tightly bound to each other and claim that language is processed in a single step (Fodor, 1983; Clark, 1992). Crain and Steedman (1985) also suggest that referential context, as well as factors, such as syntactic or semantic complexity, influences how individuals solve semantic or structural ambiguities (known as the Referential Theory; Altmann& Steedman 1988). Recent advancements in eye-tracking technology and event-related brain potentials (ERPs) have provided the platform to study comprehension processes online by monitoring the cognitive and mental processes that are activated as language unfolds (Ballard, Hayhoe, & Pelz, 1995).

For example, eye-tracking has been recently used in psycholinguistics to investigate changes in visuo-attentional processes, specifically caused by the visual context, while processing spoken language (i.e. through monitoring eye gaze; Spivey, Tanenhaus, Eberhard, & Sedivy, 2002). Spivey et al. (2002) demonstrated that when ambiguous prepositional phrases were used (e.g. "put the frog on the towel in the basket"), participants used the information that was presented in the visual-linguistic context (i.e. how the objects were arranged in the visual workspaces) to resolve the syntactic ambiguity. This preference was indicated by the allocation of appropriate eye movements towards the target object before the disambiguating point. Similar results have been observed when individuals are provided with the socio-paralinguistic context. For example, Carminati and Knoeferle (2013) presented participants with happy and sad faces of different speakers. After the presentation of each face, participants heard these speakers describing either a happy or a sad event (i.e. consistent or inconsistent with their facial expression), whilst they were presented with the pictures of those happy and sad events. They observed effects of emotion priming while participants processed the sentences online; participants were more likely to look at the picture depicting the sad event when the speaker had a sad facial expression and was describing a negative event. Furthermore, the results suggested that participants used the facial expression of the speaker to anticipate what the speaker was going to say; they were more likely to look at the happy pictures when they had been primed with a happy face.

Both of these studies applied the visual world paradigm to investigate the effect of context on language processing. This paradigm is a powerful method, providing rich and precise information regarding the time-course in which individuals combine their language skills with their knowledge of the world to comprehend language. Using this this paradigm, participants' eye movements are recorded while they listen to spoken language. At the same time, they view a visual scene that contains some of the objects and events that are mentioned in the language input. It has been found that not only do participants make appropriate eye movements towards the mentioned or related objects as the sentence unfolds (e.g. they look at a picture of a cake when they hear, "the boy will eat the cake"; Altmann & Kamide, 1999), but they also predict the unfolding language by making eye movements towards appropriate objects *before* they are mentioned in the audio input (Allopenna, Magnuson, & Tanenhaus, 1998; Carminati & Knoeferle, 2013). As such, the visual world paradigm and eye-tracking is an excellent tool to examine the real-time expectations that people have about language.

Another important technique to study real-time language processing is ERP. In particular, researchers exploring semantic/pragmatic processing have focussed on modulations of an ERP component called the N400. The N400 is a negative-going wave that peaks at about 400 milliseconds after reading/hearing a word; it is elicited by all meaningful stimuli (e.g. words and pictures). Importantly, the N400 amplitude is larger for words that are inconsistent vs. consistent with the semantic content of a sentence (Kutas, Van Petten, & Kluender, 2006). For example, the N400 is larger (more negative-going) when people read/hear a that is semantically anomalous sentence such as, "He spread the warm bread with socks" compared to a semantically congruent sentence such as, "He spread the warm bread with butter". Thus, some researchers have suggested that the N400 is an index of semantic integration (Brown & Hagoort, 1993), but more recently research has shown that the N400 is also sensitive to pragmatic meaning. For example, Hagoort et al. (2004) observed a larger N400 when participants read sentences in which the content of the sentence was inconsistent with their world knowledge, despite the sentence being semantically acceptable (Hagoort, Hald, Bastiaansen, & Petersson, 2004). For instance, Dutch participants read sentences, such as "Dutch trains are yellow/white/sour and very crowded". Since world knowledge tells participants that Dutch trains are all yellow, there was a larger N400 after hearing the word 'white', and this effect was comparable in size and timing to the semantic anomalous N400 effect (i.e. following 'sour'). The studies that were mentioned above, using online measures, show that both non-linguistic contextual factors and the semantic content of a sentence are considered at the same time when we process language.

1.4. Perspective-taking during language comprehension

One of the contextual factors that helps individuals to build coherent mental models of language is perspective. Perspective-taking, defined as the ability to represent the self and others' mental states or visuospatial perspectives, is an important skill for making successful interactions and competing with others in different domains (Baron-Cohen, 1997). As such, perspective-taking involves theory of mind (ToM)-understanding and predicting events according to other peoples' mental states (i.e. their knowledge, intentions, beliefs etc). Difficulties engaging in reciprocal conversation and building social relationships have been associated with impairments in representing others' mental states/perspectives (Rehfeldt, Dillen, Ziomek, & Kowalchuk, 2007). For example, Howlin et al. (1999) explains that in order to be successful in making conversations, one needs to consider the audience's interests, mood, level of education etc. Although, extensive research has been carried out on language and pragmatics, it has mainly focused on the relation between the individual and the environment or their world knowledge etc. (Rueschemeyer, Gardner, & Stoner, 2015). Recent research on language processing, including in this thesis, has tried to study language processing not only in terms of an individual's interactions with their environment, but also with other people, their perspectives and mental states etc. (Mohr, Rowe, Kurokawa, Dendy, & Theodoridou, 2013).

Zwaan et al. (2004), using a paradigm similar to SPV paradigm, observed that individuals were faster verifying the mentioned object, when the motion of the object in the picture matched to the perspective of the characters in the story. For instance, after being presented with the sentence "The pitcher hurled the softball to you", participants were faster verifying a picture of the ball when it appeared to be getting larger in the pictures (implying that it was getting close to them) rather than when it was getting smaller. This shows that participants simulated/adopted the perspective that was mentioned in language (Zwaan, Madden, Yaxley, & Aveyard, 2004). Furthermore, it has been suggested that while processing action words, if there are no explicit cues regarding the perspective, then individuals are more likely to adopt an agent's perspective (Beveridge, & Pickering, 2013). For example, participants are faster to make manual responses when their entities are congruent with the entities of the actions that are described in sentences (e.g. opening the drawer was processed faster and closing the drawer was processed slower when they had to move their hands towards rather than away from their bodies; Zwaan & Taylor, 2006). Thus, it seems that individuals shift perspectives while processing language online. However, what is less clear is whether this shift in perspective always happens automatically and if not, what are the specific factors and/or individual differences that encourage it.

Using sensitive online measures, evidence has built to support theories that attempt to explain which stage common ground (i.e. shared knowledge between the addressee and themselves) or others' perspectives are considered during communication, and whether these processes are activated automatically during comprehension. The most prominent theories include the perspective-adjustment model (Keysar, Barr, Balin, & Paek, 1998; Keysar, Lin, & Barr, 2003), and the constraint-based model (Nadig, & Sedivy, 2002). The perspective-adjustment model proposes that at an early stage comprehension is independent of perspective (i.e. the message is initially interpreted from an egocentric perspective), and then at a later stage the comprehender takes into account the common ground, known as the "adjustment process". This perspective adjustment process is slow and cognitively demanding. In support of this account, Keysar et al. (2000) found that when an addressee was giving participants instructions to manipulate different objects in a visual scene, they were more likely to fixate on objects that were only visible to them (i.e. egocentric perspective) than objects that were in the common ground (Keysar, Barr, Balin, & Brauner, 2000). They interpreted this as evidence for the perspective-adjustment theory, suggesting that to save resources individuals are more likely to ignore others' perspective at first and use it only when it is necessary. However, this interpretation was later challenged by Brown-Schmidt and Hanna (2011), who suggested that looks to the privileged ground (i.e. only visible to the listener) are more indicative of bottom-up lexical competition between the referents (i.e. they look at the "large candle" even though it is hidden from their interlocutor because it is the best lexical fit for the description) rather than adopting an egocentric perspective.

On the other hand, the constraint-based model suggests that perspective-taking in language is an automatic process, but depending on the context and the linguistic input, its relevance to comprehension can fluctuate (i.e. perspective is only one of many constraints that modulate language processing and depending on the situation it is weighted differently; Brown-Schmidt, & Hanna, 2011; Brown-Schmidt, Gunlogson, & Tanenhaus, 2008; Nadig & Sedivy, 2002). For example, you may simply ask your friend to pass you the "cheese" if you only have one type of cheese in the fridge but when there is more than one type of cheese in your fridge, you will specify the type of cheese you need (e.g. "blue cheese"). Evidence to support this theory has been provided by studies which showed that individuals distinguish between the common and privileged ground automatically to guide the comprehension process and resolve ambiguity (Ferguson, Scheepers, & Sanford, 2010; Ferguson & Breheny, 2011; Ferguson, Apperly, Ahmad, Bindemann, & Cane, 2015; Hanna, & Tanenhaus, 2004; Heller, Grodner, & Tanenhaus, 2008). Further evidence has been provided by Rubio-Fernández et al. (2019), who used a self-paced reading paradigm, and observed that individuals had longer reading times when the common ground was violated by a stranger, suggesting that in some conversational settings adapting the perspective or mental states of others happens automatically (Rubio-Fernández, Mollica, Ali, & Gibson, 2019).

Brown-Schmidt and Hanna (2011) suggest that individual differences between the comprehenders may contribute to the mixed findings in the area, which has also been used as evidence for the constraint-based model, showing that there are other factors which modulates the likelihood of perspective-taking in language. Executive function abilities, such as inhibitory control and working memory, the ability to empathise with others, culture and mood are some of the factors that have been put forward as potential modulators of perspective-taking in language (Bradford, et al., 2018; Brown-Schmidt, 2009; Cane, Ferguson, & Apperly, 2017; Ferguson, Cane, Douchkov, & Wright, 2015; Nilsen, & Graham, 2009; Rueschemeyer, Gardner, & Stoner, 2015; Wu, & Keysar, 2007). This growing body of research has established that individual variances exist in the use of perspective-taking in language comprehension, and has identified cognitive and social abilities as key mechanisms that underlie the ability to infer meaning in language. This work motivated the research in this thesis, investigating how autistic individuals- who manifest impairments in social communication (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997) and executive functioning (Adams & Jarrold, 2012; Williams & Jarrold, 2013) - take into account other peoples' perspectives and other social context cues when they process language online. The next section of this chapter is focused on reviewing the literature on autism, specifically some of the dominant theories of autism, and focusing on research that has examined perspective and language comprehension in autism.

1.5. Autism Spectrum Disorders

Autism spectrum disorders (ASD) are a set of neurodevelopmental conditions characterised by profound and persistent difficulties with social communication, and restricted and repetitive behaviours and interests (American Psychiatric Association, 2013). Autism is a broader term for autistic disorders, Asperger's Syndrome (AS) and Pervasive-Developmental Disorder – Not Otherwise Specified (PDD-NOS) (McPartland, Reichow, & Volkmar, 2012). It is estimated that at least 1.1% of the adult population in the UK are on the spectrum (Brugha, et al., 2016). Autistic disorder is associated with a lack of or a delay in developing language, howevernot always, since most individuals with AS show typical development of language skills. PDD refers to those who show some of the symptoms but do not fully meet the diagnostic criteria (Mandy, Charman, Gilmour, & Skuse, 2011).

Autism is associated with a wide degree of clinical heterogeneity, meaning that autistic individuals share many of the same difficulties but the extent to which these difficulties impact their everyday lives differs from one individual to another (Happé, Ronald, & Plomin, 2006). It is believed that genetic, epigenetic and environmental factors are the primary causes of this complex disorder, leading to structural and functional changes in the brain. These changes in the brain in turn cause the differences in the way these individuals process information, their cognitive functions and eventually their behaviour (Constantino & Marrus, 2017). Furthermore, so far, most of the research in the area has focused on autistic children, so little is known about language processing in autism, specifically the role of non-linguistic context on language processing. This is an important topic to study we know that many behavioral symptoms of autism improve with experience in autistic adults (known as 'compensation'), whilst the cognitive and neurological differences still persist (Livingston, & Happé, 2017). Compensation has been associated with good outcome (i.e. reaching a high degree of success in occupation/education), late autism diagnosis, female autism presentation, etc. (Livingston, & Happé, 2017). Hence, this thesis was devoted to study this topic in autistic adults.

In the next section, I will focus on four prominent theories that have been put forward to explain atypical cognitive functioning in autism, and will specifically relate their predictions to pragmatic language processing and perspective-taking in autism. These four theories include: the theory of mind impairment hypothesis (Baron-Cohen, Leslie, & Frith, 1985), the weak central coherence theory (Frith & Happé, 1994), the disordered complex information processing theory (Minshew & Goldstein, 1998), and the predictive coding theory of autism (Van Boxtel, & Lu, 2013; Van de Cruys, Evers, Van der Hallen, Van Eylen, Boets, de-Wit, & Wagemans, 2014).

1.6. Theories of autism and their implications for pragmatic language

1.6.1. The theory of mind impairment hypothesis

One of the main characteristics of autism is experiencing difficulties coping with social/unpredictable situations, which leads to socio-communication impairments, regardless of the level of language skills, IQ, etc. (Baron-Cohen, 1988). Baron-Cohen et al. (1995) put forward a hypothesis, in which for the first time they tried to explain the underlying cognitive mechanisms of these social impairments in autism. This hypothesis, which is known as the theory of mind (ToM) impairment theory suggests that autistic individuals have difficulties representing the mental sates of others, including their desires, beliefs, intentions, emotions etc. (Baron-Cohen, 2001). In typically developing (TD) individuals, the ability to attribute mental states to others is automatic and helps us to predict others' behaviours and respond in an appropriate manner (Frith & Happé, 1994). This theory derives its idea from the meta-representation model of development, suggested by Leslie (1987). Leslie states that during the second year of life children acquire the ability to pretend, meaning they learn to represent reality internally and contradict it by using pretence. This helps children to engage in 'pretend play' and start representing the abstract cognitive concepts in the self and others (e.g. mental states, thoughts, attitudes etc; Leslie, 1987). A lack of pretend play has been extensively recorded in autistic children (see Jarrold, 2003, for a review; see also Baron-Cohen, 1987; Charman, Swettenham, Baron-Cohen, Cox, Baird, & Drew, 1997; Rutherford, Young, Hepburn, & Rogers, 2007; Sigman & Ungerer, 1981).

One of the earliest and most widely used tasks to measure ToM/mind reading ability is known as the false-belief task (Wimmer & Perner, 1983). In this task, children either read scenarios or observe pictures/videos in which an agent (Sally) is interacting with an object (a ball). At some point Sally leaves the scene (or gets distracted) and puts the ball in a particular location (a basket). Then another agent (Anne) enters the scene and transfers the ball to a new location (a box) without Sally observing this action. In the testing phase, children are asked where they think Sally will look for the object when she comes back. The aim here is to see whether children can represent the mental state of the first agent and refer to the first location (i.e. where the first agent thinks the object is), rather than the second location (i.e. where actually the object is). It has been suggested that TD children can represent Sally's false belief, and use this to answer the question, between the ages of 4 to 6 (Wimmer & Perner, 1983). Braon-Cohen et al. (1985) first tested this task in autism, recruiting 20 autistic children (Age: *M*= 11:11 years) and two control groups, including 27 TD individuals (*M*= 4:5 years) and 14 children with Down's syndrome (*M*= 10:11 years). They found that autistic children were impaired in representing the false belief of the agent compared to both TD children and children with Down's syndrome. Hence, they concluded a specific lack of ToM in autism.

However, the conclusions derived from this study have been widely criticised, with some questioning this task as an appropriate measure of ToM (Bloom & German, 2000), and others suggesting that a theory of autism based solely on ToM does not fully explain the social and behavioural deficits in autism (Tager-Flusberg, 2007). Bloom and German (2000) suggest that the false-belief task is not natural and is difficult in nature. For example, to pass the test a child needs to have great language skills, be able to follow the instructions carefully, keep both locations in mind, and understand the test question correctly (i.e. understand the difference between 'where do you think Sally "would" look for the chocolate?' and 'where do you think Sally "should" look for the chocolate?').

Tager-Flusberg (2007) explains that the ToM theory of autism cannot explain some of the behavioural symptoms of autism, including repetitive and restricted behaviours and interests, face recognition impairments etc. Also, while completing tasks, such as the false-belief task, careful observations have revealed that autistic children sometimes rely on their reasoning abilities and language skills to complete the task, rather than trying to represent the mental states of others (Tager-Flusberg, 2007). This observation is supported by evidence showing intact aspects of logical reasoning and bridging inferences in autism, despite clear impairments in ToM (e.g. Black, Barzy, Williams, & Ferguson, 2019; Black, Williams, & Ferguson, 2018; Ferguson, Black, & Williams, 2019; Howard, Liversedge, & Benson, 2017a). Following these criticisms, there have been advancements in the tasks that are used to measure ToM. For example, using different forms of figurative language, including sarcasm or irony, scholars have tested second-order mental state reasoning (I.e. 'understanding what X believes about Y; Miller, 2009). Scheeren et al. (2013) compared a large sample of high functioning autistic children and adolescents (n = 194; 6–20 years) and TD individuals (n=60), using 5 different advanced ToM tasks, including understanding sarcasm, and observed that both groups had comparable performance. However, they suggest that these findings were observed under static and lab-based conditions, which may differ from real-life social situations or under time constraints and when the instructions are not as explicit (Scheeren, de Rosnay, Koot, & Begeer, 2013). Also, it has been suggested that using implicit measures, such as eye-tracking can help us understand whether individuals keep track of mental state of others implicitly and how cognitive load influences this process, which should also be further investigated in an autistic sample (Schneider, Lam, Bayliss, & Dux, 2012).

1.6.2. The Weak Central Coherence theory (WCC)

The WCC theory was first put forward by Frith and Happé (1994) to explain some of the atypicalities that are observed in autistic individuals when they complete non-social tasks or process information in general. A natural tendency to process information globally, known as the "drive for meaning", has been established in TD individuals, but the same processing style is not always observed in autistic individuals (Bartlett, 1932; Happé & Frith, 2006; Hermelin & O'Connor, 1967). The WCC theory suggests that autistic individuals are impaired at integrating information or using context to extract the top-down meaning at both perceptual and conceptual levels (i.e. getting the gist of something; Frith & Happé, 1994). For example, at a perceptual level autistic individuals struggle to process the facial features globally for extracting the facial expressions, and at a conceptual level they may be impaired at processing language in context (Teunisse & de Gelder, 2003). This theory also proposes that this global processing deficit comes hand in hand with a superior ability to attend to 'local' details (Frith & Happé, 1994). For example, autistic individuals outperform their TD counterparts in complicated visual search tasks, where finding the target object requires identifying a unique single feature (O'riordan, Plaisted, Driver, & Baron-Cohen, 2001).

Two of the first paradigms that were used to test this theory are the embedded figure task and the block design task. Both of these tasks are based on visually detecting the smaller parts/blocks from a larger figure (i.e. does not require global processing). In the embedded figure task, individuals are required to spot the hidden figures in a bigger shape. Shah and Frith (1983) tested 20 autistic children, 20 children with Down's Syndrome, and 20 TD children on the child version of the embedded figures test. They observed that the autistic children, compared to both TD children and those with Down's Syndrome, were significantly more accurate at identifying the hidden figures within each picture. They concluded that perhaps it was easier for autistic children to extract the embedded figures, since they were better at ignoring the whole picture. In another study by Shah and Frith (1993), children with autism showed superior performance on the standard Wechsler block design test, where they needed to construct 2D patterns using segmented blocks. To complete this task, children were required to segment the patterns using visual imagery, and then construct them using separate identical blocks that were provided. Numerous studies have shown that autistic individuals and those with higher autistic traits perform better on this task due to having local processing biases (Asarnow, Tanguay, Bott, & Freeman, 1987; Siegel, Minshew, & Goldstein, 1996; Stewart, Watson, Allcock, & Yaqoob, 2009; Tymchuk, Simmons, & Neafsey, 1977).

Using a language task, Frith and Snowling (1983) followed by Happé (1997) investigated how autistic individuals take into account the context when they process language. In this study, participants were asked to read sentences that included homographs (i.e. words that are spelled in the same way but have different pronunciations). To be able to pronounce the homographs correctly, participants had to rely on the context of the sentence (e.g. "In her eyes/dress there was a big tear"). They found that despite having the necessary reading skills and ToM abilities, autistic participants were impaired in using the context to interpret the target words appropriately. However, this study had a number of limitations. First of all, the task only included 5 homographs, so it is not clear whether the findings can be generalised to other homographs, and also each participant was presented with both versions of each homograph, meaning that pronouncing the first version of the word could have influenced the way they used context to pronounce the second version (Brock & Bzishvili, 2013; Hahn, Snedeker, & Rabagliati, 2015). Most importantly in these studies researchers did not control for the linguistic abilities of the participants, meaning that the results could have been due to differences in participants' ability to integrate words and paraphrases rather than WCC (Norbury, 2005). Later, Booth and Happé (2010) developed an improved paradigm to test the role of context on language comprehension. They used a sentence completion task with IQ and age matched autistic and TD adolescents, and found that the autistic participants were more likely to complete the sentences locally than globally. For example, when asked to complete the sentence, "In the sea there are fish and...", autistic participants were more likely to use a local completion word, such as “chips” rather than a global completion word, such as “sharks”, “seaweed” etc.

Recently, scholars have applied sensitive online measures to investigate autistic individuals’ ability to integrate context when they process language online. Brock et al. (2008) were the first to use eye-tracking to investigate how people with and without autism use the semantic context to resolve phonological ambiguity. They found no differences between groups in terms of context sensitivity, however those with poor language abilities performed significantly worse (Brock, Norbury, Einav, & Nation, 2008). This intact use of context has been replicated several times in studies that have used online measures and when cognitive factors, such as linguistic skill, are controlled for (Au-Yeung, Kaakinen, Liversedge, & Benson, 2015; Black, Barzy, Williams, & Ferguson, 2019; Ferguson, Black, & Williams, 2019; Hahn, Snedeker, & Rabagliati, 2015; Howard, Liversedge, & Benson, 2017a). Based on what was discussed, it seems that autistic individuals with better language skills may be able to integrate the context and the linguistic input online. However, in most of these studies participants had either to take into account their world knowledge or emotional states of characters that were described explicitly. It would be interesting to see how these individuals perform when these contextual factors are socially related and/or are more implicit (e.g. social stereotypes, their physical perspectives and implicit mental/emotional states in non-literal language etc.).

1.6.3. Disordered Complex Information processing theory

This theory was first proposed by Minshew and Goldstein (1998), describing autism as a developmental disorder that is associated with impairments in processing complex information at a neural level and not specified to a single function or system. They suggested that autistic people have intact or even enhanced abilities in processing simple tasks from different domains of cognition, such as language, memory etc. but at the same time, they struggle with processing more complex and demanding information from the same domains (i.e. higher order tasks; Minshew, Johnson, & Luna, 2000; Minshew, Sweeney, & Luna, 2002). Therefore, this theory suggests that autistic individuals struggle more with the level of complexity (its amount and time constraints) rather than its nature (memory, motor, language, etc.).

This theory was based on the findings of a study, in which 33 autistic and TD age and IQ matched participants were tested on battery of attention, memory, language, sensory perception, motor and problem-solving tasks (Minshew, Goldstein, & Siegel, 1997). The aim was to see whether the impairments were primarily specific to a single domain or whether they were present across the majority of these domains and if so, what were the common features among them. The results demonstrated that autistic individuals struggled to complete the complex and higher-order tasks of interpretive language, memory and some of the sensory processing tasks, but they had intact abilities on simple cognitive tasks, such as spelling, vocabulary etc. The common feature between these impairments was the higher-level of the task demands while processing and integrating them from various domains (specifically within the social, memory, communication and motor domains). Therefore, Minshew and colleagues concluded that autism is not the result of impairments in a single domain but rather across the whole neural network (Minshew, Goldstein, & Siegel, 1997). This model specifically predicts that the local neural networks are intact but there is an under-connectivity across these networks, which affects the performance on tasks that require integration of information from different modalities (Just, Keller, Malave, Kana, & Varma, 2012).

Neuroimaging evidence further supports this theory by showing less executive connectivity between different areas of an autistic person's brain. This underconnectivity was only observed when they were completing tasks that required co-ordination between different networks, such as problem-solving tasks, social thinking tasks, and tasks that required both language and theory-of-mind networks (Just, Cherkassky, Keller, Kana, & Minshew, 2006; Kana, Keller, Cherkassky, Minshew, & Just, 2009; Mason, Williams, Kana, Minshew, & Just, 2008). There are also several lines of evidence supporting this theory using eye-tracking (Au-Yeung, Benson, Castelhano, & Rayner, 2011; Au-Yeung, Kaakinen, & Benson, 2014; Benson, Castelhano, Au-Yeung, & Rayner, 2012). For example, Au-Yeung et al. (2011) found no difference between the eye movement patterns of TD and autistic individuals when they were completing a simple "spot the difference" task, where participants were simply required to indicate which pair of images were not identical. On the other hand, while completing a "which one's weird" task (they had to spot the picture that look weird or strange in some way), autistic participants took longer to respond, made more fixations before finding the weird target region, and had shorter first fixation durations on this region. First fixation duration refers to the duration of fixating a region for the first times and is an indication of the processing difficulties that people experience while processing a region for the first time. The fact that TD participants had longer first fixation durations shows that contrary to autistic participants, they immediately spotted the weird regions. Thus, the autistic participants faced difficulties completing the complex but not the simple information processing task (Au-Yeung et al., 2011). Further evidence for this theory comes from the linguistic and pragmatic differences that have been observed between autistic and TD individuals. Minshew et al. (1995), observed that high functioning autistic participants had intact abilities in completing simple tasks, such as visual auditory, grammar learning, word identification and word comprehension, but struggled with tasks that needed higher-order cognitive functions, such as passage comprehension, synonym identification, making inferences and understanding metaphoric expressions. They suggested that perhaps this is due to disassociations between basic language abilities that are completed by relying on associative processes and those that require combining information from different modalities, such as interpretative skills which put higher pressure on our cognitive skills, such as working memory, attention shifting etc. (Minshew, Goldstein, & Siegel, 1995).

1.6.4. The Predictive Coding theory of autism

Similar to WCC and the complex information processing theories, the predictive coding hypothesis also identifies autism as a perceptual disorder rather than a social one (Van Boxtel & Lu, 2013). This theory considers the brain as an anticipating machine that constantly generates different predictions or mental models and tests them in different situations. These models/predictions make us efficient and prepare us to react in unforeseen circumstances (Clark, 2013). These predictions are based on our prior experiences, helping us to explain and make sense of the sensory input we are currently receiving from lower level brain areas. Consequently, they build a bigger picture of what is happening around us and help to generate responses that are appropriate based on the situation (Van Boxtel & Lu, 2013; Van de Cruys et al., 2014).

In some cases, these predictions are not correct or precise enough (i.e. violating expectations), which results in prediction errors. These prediction errors help the brain to update and generate new predictive models, but at the same time they may not be informative and should be ignored. The predictive coding theory suggests that autism is the result of difficulties attributing weights to these prediction errors (Van de Cruys et al., 2014). In other words, due to metacognition impairments autistic individual experience a constant struggle with when and why these prediction errors should be ignored or taken into account, especially in new situations where we rely most strongly on predictive models and prediction errors. This results in becoming attuned to details, feeling overstimulated by sensory input (i.e. hypersensitivity), and failing to see the bigger picture (Van de Cruys, de-Wit, Evers, Boets, & Wagemans, 2013). The chronic hypersensitivity to these prediction errors leads to a lack of exploration, and developing an attitude of avoiding new situations/experiences (Van de Cruys, et al., 2014).

The predictive coding theory has been specifically applied to social communication. Social situations are one of the most unpredictable situations that we face in every-day life (Lawson, Rees, & Friston, 2014). Each social situation is unique and using our meta-cognitive abilities allows us to learn that there are many factors in these situations that should be ignored and many that need to be prioritised (i.e. modulating our attention resources). For example, laughter, which is universally perceived as a signal of happiness in social situations, signals different things and is highly contextually-bound. Sometimes we laugh to be ironic or even to show resentment and disappointment. Consequently, in social situations we rely the most on predictive models. We realise that our prediction errors are sometimes uninformative and should only be taken into account flexibly (Van de Cruys et al., 2014). Thus, since autistic individuals struggle to regulate the precision of prediction errors it is not surprising that they struggle with social situations.

During social interactions individuals should also be able to integrate the sensory signals from different modalities, such as processing the visual input, speech perception and higher cognitive abilities, including ToM, emotional recognition etc. It is known that autistic individuals struggle with these integration processes, which is associated with hypersensitivity to prediction errors in autism (Iarocci & McDonald, 2006). This hypersensitivity may prevent the optimal integration of sensory input, especially if these signals indicate an inconsistency (Van de Cruys et al., 2014). Thus, the social difficulties that autistic people face could be independent of their linguistic skills and more related to integration processes from different modalities. In the next section, I will review the literature on language and context processing in autism.

1.7. The time-course of language comprehension and context integration in autism

Autistic characteristics, including language skills, can vary significantly from one individual to another (Tager-Flusberg, Paul, & Lord, 2005). However, most autistic individuals have profound difficulties in social communication. Iarocci and McDonald (2006) stated that during face to face social interaction, we need to integrate the sensory input from different modalities with higher cognitive functions, such as ToM, embodying the perspective adopted in text, our world knowledge etc. In other words, as well as processing text, we are required to mentally simulate the language and integrate the context as we proceed. However, most of the theories discussed above agree on context insensitivity and impairments in top-down processing in autism, but far too little attention has been paid to the time-course of these integration processes in language use in autism (Lawson et al., 2014).

This topic has recently begun to be examined in autism, as described in some of the research above (e.g. Au-Yeung et al., 2015; Black, et al., 2019; Booth & Happé 2010; Brock, et al., 2008; Ferguson et al., 2019; Hahn et al., 2015; Happé, 1997; Howard et al., 2017a). across these studies, depending on the factors that groups were matched on (e.g. "IQ, language skills etc.") and the measures that were used, the findings were mixed. However, even in the studies that found no group differences in terms of context sensitivity, the autistic groups still showed subtle processing difficulties. For example, Howard et al. (2017a) observed a short delay when autistic individuals were integrating the linguistic input with their world knowledge. Ferguson et al. (2019) also found that autistic groups in general had longer reading times when processing counterfactual events, showing that the two groups might employ comparable strategies to facilitate comprehension, but the autistic adults may find it more cognitively effortful to do so. This was associated with a more cautious reading strategy under high processing load or having difficulties mentally simulating the language online, supporting the underconnectivity and complex information processing theory of autism (Just et al., 2004; Minshew & Goldstein, 1998). In fact, evidence from embodiment research also supports the notion that autistic individuals struggle with building mental models of text while they comprehend language. For example, Peleg et al. (2018) demonstrated that while processing language, autistic individuals simulated different dimensions of the text in a less automatic way compared to TD individuals (Peleg, Ozer, Norman, & Segal, 2018). Further evidence to support general processing difficulties in autism has been provided by Sansosti, Was, Rawson, & Remaklus, (2013). They used eye-tracking to explore the cognitive mechanisms that underlie inferential processing during text comprehension. The behavioural data suggested that autistic individuals, similar to TD participants, had intact abilities to make inferences and comprehend the text but the eye movements revealed longer fixations in the autistic group. They suggested that autistic participants were able to build the implicit inferences while reading the text but they faced difficulties incorporating them while they had to build the mental models (Sansosti, et al., 2013).

A few studies have used ERPs to study this topic in autism, however compared to the eye-tracking studies these are much more limited. Lui et al. (2018) used ERPs to investigate the time-course in which individuals with high and low numbers of autistic traits (measured using the Autism Spectrum Quotient questionnaire or AQ) integrated negative and positive words when spoken with happy and sad prosody. They found that people with more autistic traits showed a delay in judging the emotional valence of words, regardless of the condition (i.e. whether the emotional valence of speech matched or mismatched the meaning of the words). Hence, at a behavioural level both groups integrated the prosody of the speech and the linguistic input in a similar time course. However, people with less autistic traits elicited a significantly larger N200 and N400 when there was an inconsistency in the emotional speech, meaning that they found it harder to semantically integrate the linguistic input, when there was an inconsistency between the prosody and the meaning of the words spoken. This significant effect was not observed in those with more autistic traits (Lui, So, & Tsang, 2018). The researchers concluded that this was an indicator of reduced automaticity to combine the prosody with the linguistic input in those with a higher number of autistic traits. However, the sample used in this study only included individuals from a non-clinical sample, which makes it hard to generalise the findings to a clinical autistic sample. Plus, this study did not include any semantically anomalous sentences to be used as the baseline of N400 effects. In sum, the studies that have used ERPs to study language processing in autism have yielded mixed findings to date, with some showing an intact N400 response to contextually inconsistent content in autism, and others showing a reduced N400 amplitude. Even its absence, it is not clear whether Lui et al.'s findings (2018) reflected an overall reduced N400 in people with higher AQ scores (i.e. higher number of autistic traits) or an impaired sensitivity to the manipulation of prosody (Coderre, Chernenok, Gordon, & Ledoux, 2017; Dunn, & Bates, 2005; Fishman, Yam, Bellugi, Lincoln, & Mills, 2010; Pijnacker, Geurts, Van Lambalgen, Buitelaar, & Hagoort, 2010).

In another study, Ishikawa et al. (2017) tested how individuals with low and high AQ scores combine the mental states of story characters with language. In this study, participants read short passages while ERPs were recorded. Passages either included the true or false belief of one of the characters or the passages did not refer to the characters' mental states at all. In the last sentence of each passage, participants read words that were either expected or unexpected based on the context of the passage (i.e. belief expected or belief unexpected vs. no belief-expected, no belief-unexpected; Ishikawa, Itakura, & Tanabe, 2017). Results revealed a larger N200 effect (i.e. a marker of distinguishing an unexpected stimulus) in the no belief-unexpected condition compared to the no belief-expected condition, regardless of the AQ scores. Thus, people in both groups showed sensitivity to the word that did not fit with the events of the story. Analysing the P300 (i.e. a response to context deviation) revealed a larger P300 in individuals with low AQ scores in the unexpected *vs.* expected conditions (in both belief and no belief categories). This pattern was also present in individuals with high AQ scores, but it was only marginal. Hence, it can be concluded that participants with high AQ scores showed some indication of integrating mental states with the linguistic input, but this effect was smaller or perhaps less automatic compared to participants with low AQ scores. To the best of my knowledge, only a handful of other studies have used implicit measures, including ERPs and eye-tracking methods to study the integration processes of linguistic input and the socio-emotional context in autism and how these processes impact the quality of their social interactions in real-life, so there remains a gap in the literature on this topic.

1.8. Thesis Plan

Following the literature discussed in this chapter, the broad aim of this thesis was to understand some of the cognitive mechanisms that underlie social communication difficulties in autistic adults. Specifically, this thesis focuses on the time-course in which the non-linguistic context (i.e. perspective, social stereotypes, emotions etc.) is integrated with the language input and whether these processes are comparable in autistic and on-autistic adults. Based on the literature discussed, it seems that the important question to ask is not whether autistic individuals can integrate the context while they process language, but rather whether there are any contextual factors (i.e. mental states, emotions) that these individuals struggle to integrate. In other words, under what conditions do people with autism struggle with these integration processes. In this thesis, I will present seven experiments that used behavioural, eye-tracking and ERP methods to examine these integration processes. As mentioned before, this is an understudied topic, especially in autistic adults, and temporally sensitive online measures have rarely been applied.

In the first empirical chapter of this thesis (Chapter 2), I present three experiments that examined the influence of personal pronouns and visual perspective on language comprehension and memory in non-autistic individuals. Here, I attempted to replicate some of the well-established effects of perspective simulation using behavioural measures, with the aim to later apply these tasks in autistic individuals. However, in all three experiments I failed to to obtain the original findings, thus I shifted my focus away from simulations of perspective in language, and instead used sensitive online measures to examine the time-course of social inferences and meaning in the next experimental chapters. In Chapter 3 I present two pre-registered experiments that investigated how autistic and non-autistic individuals take into account social stereotypes and perspective to infer meaning when processing spoken language online. I used eye-tracking and ERPs to investigate the temporal nature of anticipation and integration processes underlying these effects. Chapter 4 used a pre-registered eye-tracked reading paradigm in which participants read narratives about a character (victim) who was either amused or upset when another character (protagonist) criticised their actions using ironic or literal language. The aim was to examine readers' ability to keep track of the different story characters' emotional states online while reading, and test their ability to integrate higher order mental states, such as emotions. In the final empirical chapter of this thesis, I used mobile eye-tracking (pre-registered) to study eye movements while autistic and non-autistic individuals engaged in real-life social interactions that required them to mentalise about the self *vs.* others. All experiments also included some standard cognitive tasks (e.g. to assess individual differences in verbal abilities, theory of mind, and central coherence) to explore some of the cognitive mechanisms that might underlie these processes.

Chapter 2: Revisiting the role of personal pronouns on perspective taking during discourse comprehension

In the first chapter of this thesis I introduced the idea that successful comprehension is based on extracting meaning from language, interpreting it in context, and embodying the events in a story rather than processing the linguistic structures in isolation. However, little research has been conducted on the factors that influence these processes in autism. In this chapter I aimed to look at the influence of visual perspective and personal pronouns on language comprehension in non-autistic individuals. First, I tried to replicate some of the well-established effects in this area using behavioural measures, before testing the effect in those with autism. However, the failure to find the same findings motivated me to use online and sensitive measures for the next experimental chapters. Therefore, the first experimental chapter of this thesis is devoted to the attempts that I undertook to validate the tasks that have been used to test the perspective modulations in language simulation, before recruiting the autistic individuals.

The situation model theory suggests that while comprehending language online, comprehenders constantly construct and update their representations of what is described in the text (Zwaan & Radvansky, 1998; Bower & Morrow, 1990; Glenberg, Meyer, & Lindem, 1987). In other words, individuals build mental models of the events and characters in a story, their goals/intentions etc, and update these online to keep track of their epistemic states. Moreover, it has been proposed that language goes beyond the simple representations of situations; it is grounded in action and perception (individuals tend to mentally simulate the descriptions of events), which facilitates communication (Zwaan, 2004). For example, while reading descriptions of action events (e.g. "kick the ball"), comprehenders activate an internal simulation of those particular events. This is known as the “embodied view” of language processing (Zwaan, 2004; Zwaan, & Madden, 2005).

Evidence to support the embodied view has been provided by studies in which either sensorimotor effects were observed when action words were processed, or these sensorimotor effects influenced the comprehension processes (Lindsay, Scheepers & Kamide, 2013; Zwaan, & Taylor, 2006; Buccino, Riggio, Melli, Binkofski, Gallese, & Rizzolatti, 2005). For example, neuroimaging studies have revealed that processing action words associated with specific body parts (e.g. arm-pull) activates consistent brain regions, including areas of the motor and pre-motor cortex, that are involved in perceiving or performing those motor actions with the same effectors (e.g. Martin & Chao, 2001; Pulvermüller, 1999; 2002; Vigliocco, Vinson, Druks, Barber, & Cappa, 2011). Further evidence has been produced from researchers using eye-tracking to show that individuals simulate the speed of motion verbs (Lindsay et al., 2013). While viewing visual scenes involving an agent, the path and the goal, participants were more likely to look at the path while hearing sentences that included slow verbs (e.g. “dawdle”), but more at the goal for sentences that included fast verbs (e.g. “dash”). These findings show that listeners in this study dynamically represented the motion events while listening to the language descriptions.

Previous research has widely examined whether comprehenders adopt different perspectives while processing language (i.e. from an actor’s *vs.* an observer’s point of view), and which linguistic factors might influence this process. Perspective has been shown to enrich the specificity of linguistic representations. For example, personalized descriptions (i.e. text introduced with a first or second person pronoun) activate more vivid representations of described events (Jackson, Brunet, Meltzoff, & Decety, 2006) and enhance memory for text (Berry, Michas, & Bersellini, 2003) compared to third person perspective. Moreover, readers report feeling more immersed in fiction text, and are more accurate at detecting errors/changes in text when it is written from a first person perspective (Ferguson & Jayes, 2018; Fukuda & Sanford, 2008). Barsalou (2008) suggested that actions that are described in text are constantly simulated from an actor's perspective. In contrast, Black, Turner and Bower (1979) stated that individuals dynamically switch between the different perspectives that are represented in the text. Black and colleagues showed that during discourse comprehension, a change in the spatiotemporal perspective influences reading times, meaning that mental models were represented from different perspectives, and shifting between them involved extra processing costs. In fact, research has shown that pronouns are one of the linguistic cues that can mediate the perspective adopted by individuals while reading narratives. Various studies have found evidence to support this effect, by showing that people mentally simulate the described actions from an internal/their own point of view when personal pronouns ("I/you") are used, but simulate the described actions from an external/someone else's point of view for third person pronouns ("he/she"; e.g. Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009; Brunyé, Ditman, Mahoney, & Taylor, 2011; Papeo, Corradi-Dell'Acqua, & Rumiati, 2011; Fields & Kuperberg, 2012; Sato & Bergen, 2013).

Using a SPV task, Brunyé et al. (2009) presented participants with single sentences that described actions being performed, and included different pronouns to indicate the perspective of the action (e.g. "I am/you are/he is slicing the tomato"). Next, participants were presented with pictures showing the described the action, either from an internal or external perspective. They were required to respond according to whether the action in the pictures matched to those described in the sentences. Participants were faster responding to pictures that were presented from an internal vs. external perspective following the pronouns ‘you’ and ‘I’, but faster to pictures presented from an external vs. internal perspective following the pronouns ‘he/she’. In their second experiment, Brunyé and colleagues extended these findings using short narratives rather than single sentences (e.g. “I am a 30-year-old deli employee. I am making a vegetable wrap. Right now, I am slicing the tomato”). They observed the same pattern of internal/external embodied language processing for pronouns ‘you’ and ‘he/she’, respectively. However, the pronoun ‘I’ led to shorter reaction times when followed by pictures depicting events from an external *vs.* internal perspective. This finding contradicts the results from Brunyé’s first experiment, where an internal perspective preference was observed for the pronoun ‘I’. The authors claimed this difference was due to the ambiguous nature of the characters in the 1st experiment, which encouraged participants to adopt an internal perspective. They claimed that this ambiguity was resolved in the second experiment by providing context. As mentioned before, this personalisation effect has been replicated in different experiments, however findings are somewhat mixed, in relation to which pronoun participants are more likely to internalise (i.e. ‘you’ vs ‘I’; Brunyé, et al., 2011; Papeo, et al., 2011; Fields & Kuperberg, 2012; Sato & Bergen, 2013).

However, subsequent research has shown that these effects of perspective on simulations of language are not universal. A growing body of evidence has shown that individual differences and situational factors, such as empathy, imagination, visual imagery, perspective taking, spatial reference biases influence the likelihood and nature of mental simulations during reading (Brunyé, Ditman, Giles, Holmes, &

Taylor, 2016; Hartung, Hagoort, & Willems, 2017; Komeda, Tsunemi, Inohara, Kusumi, & Rapp, 2013; Ruby & Decety, 2001). For instance, a greater degree of similarity between the protagonist and reader has been shown to elicit stronger mental simulations of language, and participants who score higher on empathic engagement or immersion during literary reading are more likely to mentally simulate the perspectives described in the text (Brunyé, et al., 2016; van den Hende, Ellis, Dahl, Schoormans, & Snelders, 2012). The studies presented in this first empirical chapter therefore aimed to establish the effect of personalisation on language simulations and understanding, using the standard SPV procedures and pronoun manipulations from previous research (described above). Importantly, the experiments presented in this chapter sought to validate these paradigms and perspective simulation effects to inform further experiments that could test whether comparable effects of language simulation and personalisation are elicited among autistic individuals.

2.1. Experiment 1

Experiment 1 adapted Brunyé et al.'s (2009) SPV paradigm (Experiment 1). In this task, participants were presented with sentences, using first, second or third person pronouns, which described different daily actions being performed (e.g., "I am/you are/he is slicing the tomato"). Participants were then presented with pictures that depicted the described action, either from an internal perspective (i.e. hands performing the action from the participant's point of view) or from an external perspective (i.e. another person's hands performing the action, with the participant an observer). Filler items were also included, in which the actions in the sentences and pictures did not match. Participants' task was to indicate whether the action depicted in the picture matched the action mentioned in the sentence, and accuracy and response times were recorded to indicated ease of processing.

The sentences used in Experiment 1 were based on those used in Brunyé's (2009) study. The structure of sentences (e.g. "I am/you are/he is slicing the tomato") and basic procedure was identical, but the current study updated the action pictures to be more ecologically valid and increased the number of experimental items. The pictures in Experiment 1 showed the actions in real-life settings, whereas Brunyé and colleagues created tightly controlled pictures with a plain white background to make the action event and hands more salient. The actions in this study were presented in more complex real-life contexts, which meant that backgrounds were highly varied (see Figure 2.1.).

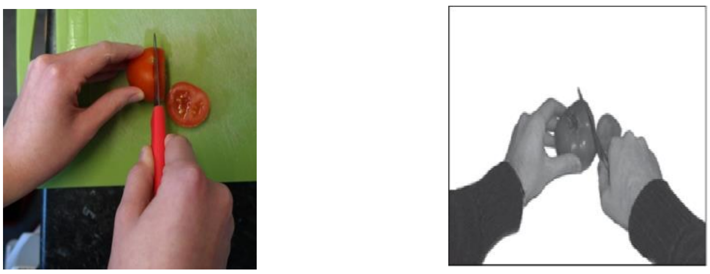

Figure 2.1. Example of an experimental picture from Experiment 1 (on the left) vs. Brunyé's experiment (on the right), that could be paired with the sentence, "I am/you are/he is slicing the tomato".

Based on the proposal that personal pronouns ("I/you") activate a simulation of events from an internal perspective, but third person pronouns activate a simulation of events from an external/ perspective, we expected to observe distinct simulations of perspective for actions using different pronouns (as seen in Brunyé et al., 2009; Brunyé et al., 2011; Papeo et al., 2011; Fields & Kuperberg, 2012; Sato, & Bergen, 2013). Specifically, it was hypothesised that participants would be more accurate and faster to respond to pictures in which the presented perspective matched the pronoun in the sentence. That is, participants should be faster responding to the external pictures when the pronoun "he/she" was presented, but faster responding to the internal pictures for the pronouns "you" and "I".

2.1.1. Methods

2.1.1.1. Participants

Thirty-one undergraduate students, (27 females and 4 males, *M* age= 21.71, *SD* age= 7.11, age range 18-49) from the University of Kent were recruited to take part in this study in return for course credits. Participants were recruited through the School of Psychology's online Research Participation Scheme (RPS). All participants were native speakers of English, and none had a diagnosis of dyslexia or reading comprehension impairment.

2.1.1.2. Materials and design

This study used a repeated measures design, crossing 3 (pronoun: I *vs.* you *vs.* he/she) x 2 (perspective: internal *vs.* external) within-subject independent variables. Participants' accuracy and response times to respond to the images were the dependent measures.

Descriptive sentences: One hundred and ninety-two descriptions of daily life events (90 experimental, 90 filler and 12 practice items), similar to those in Brunyé et al. (2009) were created. These were presented to participants with one of three pronouns: "I", "you", or "he/she". All sentences were similar in terms of the structure: pronoun (I/you/he/she) + verb (am slicing/are slicing/is slicing) + object (the tomato). Three versions of each experimental sentence were created, one for each of the pronouns (i.e. 3 lists of sentences), and filler/practice sentences were divided included an equal number of each pronoun.

Event pictures: Each experimental sentence was paired with one of two pictures; one represented the described action from an internal perspective, and the other represented the same action from an external perspective (See Figure 2.2. for an example). Pictures measured 400x400 pixels, and the actions were depicted in real life contexts (i.e. not on plain white backgrounds). For the experimental items, the events in the sentences and pictures always matched. However, for the filler items, the actions in the pictures and sentences did not match. Hence, there were equal numbers of matching and mismatching items. For filler items, there were only one version of each picture, half representing the action from an internal and the other half presenting the actions from an external perspective.

Figure 2.2. An example of an internal and an external experimental image that could be paired with the sentence, "I am/You are/She is slicing the tomato".

2.1.1.3. Procedure

Participants were randomly assigned to one of six lists (3 pronouns x 2 perspectives) to complete the task, so that each participant saw each experimental item once, but only in one condition. The sentences in each list were randomly and equally distributed across each pronoun and perspective (15 experimental items in each condition). Participants were asked to read each sentence carefully and respond as quickly and as accurately as possible to whether the actions described in the sentences matched to the actions depicted in the pictures. They were instructed to press the “Y” key on the keyboard when the action described in the sentence matched that depicted in the picture, and “N” when they mismatched. They completed 12 practice trials (6 matching, and 6 mismatching) before moving to the experimental trials. The items were presented in a random order, and there were equal number of “yes” and “no” responses in each list.

At the start of each trial, a fixation cross was presented on the screen for 500ms and then the sentence appeared on the middle of the screen and it remained on the screen for 2000ms. Participants were then presented with a blank screen for 500ms, before the picture appeared on the screen. Pictures stayed on the screen until participants responded, but if they did not respond within 3000ms, the trial automatically ended and proceeded to the next trial. During the practice block, participants received feedback to make sure they understood the instructions.

2.1.2. Results

Only experimental trials were included in the analysis, so the practice and filler trials were discarded. Accuracy and response times were analysed using a 3 (pronoun: “I” vs. “you” vs. “he/she”) x 2 (perspective: internal vs. external) repeated measures analysis of variance (ANOVA).

2.1.2.1. Accuracy

Accuracy was defined as the percentage of trials in which participants correctly responded that the events described in the sentences matched to those depicted in the pictures. Analysis revealed a significant main effect of perspective ($F(1, 30) = 7.68$, $p = .009$, $\eta p2 = .20$), with participants overall more accurate when responding to pictures with an external perspective (*M*=96%) than an internal perspective (*M*=94%). Neither the main effect of pronoun (F(2, 60) = 0.48, *p* = .622) or the interaction between pronoun and perspective (F(2, 60) = .12, *p* = .889) were significant.

Table2.1. Means and SEs (in brackets) of accuracy (%) and response time (ms) in each condition for Experiment 1.

		Pronouns		
		I	You	He/She
Accuracy	**Perspectives** Internal	93.98 (1.25)	93.33 (1.20)	93.33 (1.11)
	Perspectives External	96.56 (.87)	95.05 (1.20)	95.91 (1.01)
Response times	**Perspectives** Internal	661.20 (24.94)	648.47 (22.24)	691.27 (27.78)
	Perspectives External	664.00 (24.19)	640.78 (23.72)	639.05 (20.28)

2.1.2.2. Response times

Response times were measured from picture onset (in milliseconds) until participants responded, and only correct responses were included in the analysis. The analysis showed that neither the main effect of pronoun (F(2, 60) = 2.31, *p* = 0.108) or perspective (F(2, 30) = 2.14, *p* = 0.154) reached significance. However, the interaction between the pronoun and perspective was marginally significant [F(2, 60) = 3.01, *p*= 0.057, ηp2 = .09]. Since previous work and our hypotheses predicted this interaction, we explored this effect further using Bonferroni-adjusted comparisons, which revealed that participants were faster responding to external pictures (*M*=639ms) compared to internal pictures (*M*=691ms) when the sentence included the external pronoun "he/she" (t=2.68 , p=0.012). In contrast, response times for internal versus external pictures did not differ when the sentence included an internal pronoun, "I" or "You" (all *t*s< 0.39, all *p*s> 0.700).

2.1.3. Summary

The aim of Experiment 1 was to obtain the same findings from previous studies, which have shown that choice of pronoun influences the perspective that individuals adopt (i.e. internal versus external) while simulating language (Brunyé et al., 2009; Brunyé et al., 2011; Papeo et al., 2011; Fields & Kuperberg, 2012; Sato, & Bergen, 2013). We applied a SPV paradigm, similar to that used in previous research, in which participants' accuracy and response times were recorded, however the results were only partially in line with the previous findings. On one hand, participants were faster responding to pictures that depicted actions from an external (versus internal) perspective following the external pronoun 'he/she', which suggests that the external perspective was facilitated following the third person pronouns (in line with previous findings; Brunyé et al., 2009). However, there was no evidence of an internalisation effect (i.e. faster responses to pictures that depicted actions from an internal (versus external) perspective following personal pronouns "I" or "you". In addition, participants were overall more accurate responding to pictures that depicted actions from an external perspective compared to an internal perspective, but this effect was not modulated by the preceding pronoun.

At this point, it is important to highlight some differences in the materials used in Experiment 1 compared to those used in Brunyé et al. (2009). Specifically, the current study included a larger number of experimental items, pictures depicted actions in complex natural environments, and the sample size was smaller than the original. Thus, it is possible that the failure to find similar findings as Brunyé's in Experiment 1 was due to these differences in number and complexity of materials. To test this possibility, and ensure that our experiment was based as closely as possible on the original designs, we conducted a second experiment with TD participants using materials from one of the previous studies that have shown personalisation effects in language comprehension. Unfortunately, we were not able to access Brunyé's (2009) materials due to confidentiality issues, however our Experiment 2 directly replicated the materials, design and procedures used by Sato et al. (2013; Experiment 3), since they successfully replicated the original effect using Brunyé's paradigm and were generous enough to share their full materials. Sato only used pronouns 'he' and 'you' in her study and only used discourse scenarios, rather than single sentences but since the personalisation effects seems to be more consistent for the pronoun 'you', I decided to do the same in experiment 2.

2.2. Experiment 2

2.2.1. Method

2.2.1.1. Participants

Sixty-four undergraduate students (56 females and 8 males, *M* age= 21.16, *SD* age= 6.74, age range 18-54) from the University of Kent were recruited to take part in this study in return for course credits. Participants were recruited through the School of Psychology's online Research Participation Scheme (RPS). All participants were native speakers of English, and none had a diagnosis of dyslexia or reading comprehension impairment.

2.2.1.2. Materials and design

This study employed a 2 x 2 repeated measures design, including pronoun (you vs. he) and perspective (internal vs. external) as the within-subjects variables. Participants' accuracy and response times were recorded for analysis (measured as before).

Descriptive sentences: Twenty-four sets of sentences (each set included 3 sentences), were used as experimental items, and these were taken directly from Sato et al.'s study (2013). There were two versions of each set based on the pronoun included in the sentences ("you" or "he"). The first sentence always introduced the protagonist, using "you" in the first person pronoun condition, and a proper name in the third person pronoun condition (e.g. "You are/John is a librarian"). The second sentence provided further context for the protagonist (e.g. "You are/He is checking the due dates"), and the third sentence described the protagonist performing an action (e.g. "you are/He is opening the book right now"). An additional 36 sets of sentences were taken from Sato et al.'s study (2013) as filler and practice items (24 filler items and 12 practice items). Half of the filler and practice items were presented using the pronoun "you" and the other half using the pronoun "he".

Event pictures: Each experimental sentence was paired with one of two pictures; one represented the described action from an internal perspective, and the other represented the same action from an external perspective (See Figure 2.3. for an example). Pictures measured 400x400 pixels, and the actions were depicted in colour on plain white backgrounds. For the experimental items, the events in the sentences and pictures always matched. However, for the filler items, the actions in the pictures and sentences did not match. Hence, there were equal numbers of matching and mismatching items. For filler items, there were only one version of each picture, half representing the action from an internal and the other half presenting the actions from an external perspective.

Figure 2.3. An example of an internal and an external experimental image, that could be paired with the sentences, “You are/John is a librarian. You are/He is checking the due dates. You are/He is opening the book”.

2.2.1.3. Procedure

Participants were randomly assigned to one of four lists (2 pronouns x 2 perspectives), so that each participant saw each experimental item once, but only in one condition. The sentences in each list were randomly and equally distributed across each pronoun and perspective (6 experimental items in each condition). Participants were instructed to read each sentence carefully and respond as quickly and as accurately as possible to whether the actions described in the sentences matched the actions depicted in the pictures. They were instructed to press the “Y” key on the keyboard when the action described in the sentence matched that depicted in the picture, and “N” when they mismatched. As mentioned before, the depicted and described actions always matched in the experimental items and they always mismatched in the filler items (making equal numbers of “Y” and “N” responses). They completed 12 practice trials (6 matching, and 6 mismatching) before moving to the experimental trials. The items were presented in a random order, and there were equal number of “yes” and “no” responses in each list.

At the start of each trial, a fixation cross was presented on the screen for 500ms, then each of the three sentences appeared one by one in the middle of the screen for 2000ms each[2]. This was followed by another fixation cross for 500ms. Finally, the event picture was presented and remained on the screen until participants responded, or timed out and proceeded to the next trial after 3000ms. During the practice block, participants received feedback to make sure they understood the instructions.

2.2.2. Results

Only experimental trials were included in the analysis so practice and filler trials were discarded. The accuracy and response times were analysed using a 2 (pronoun: “you” vs. “he/she”) x 2 (perspective: internal vs. external) repeated measures ANOVA. The descriptive data are shown in Table 3.

2.2.2.1. Accuracy

Analysis revealed that neither the main effect of pronoun (F (1, 63) = 1.09, *p* = 0.300) nor the main effect of perspective (F (1, 63) = 1.82, *p* = 0.182) was

[2] This is longer than the 1500ms used in Sato’s study, but piloting suggested that 1500s was too short for some of the longer sentences in English.

significant. The interaction between pronoun and perspective variables was also non-significant (F(1, 63) = 3.05, p = 0.086).

Table 2.2. Means and SEs (in brackets) of accuracy (%) and response time (ms) in each condition for Experiment 2.

			Pronouns	
			You	He
Accuracy	**Perspectives**	Internal	96.35 (1.14)	96.88 (0.90)
		External	98.96 (0.51)	96.61 (0.92)
			You	He
Response times	**Perspectives**	Internal	627.53 (26.64)	636.26 (26.39)
		External	617.43 (23.49)	642.20 (33.41)

2.2.2.2. Response times

Response times were measured from the onset of pictures on the screen (in milliseconds) until participants responded. Only trials in which participants correctly responded to the presented stimuli were included in the analysis. In addition, we adopted the same exclusion criteria as Sato's study, whereby response times that were more or less than 2.5 x standard deviation of the mean were excluded from the analysis. Results showed that neither the main effect of pronoun (F(1, 63) = 1.69, p=0.198) or perspective (F (1, 63) = 0.50, p=0.823), or the interaction between pronoun and perspective (F (1, 63) = 0.58, p=0.449) reached significance.

2.2.3. Summary

In Experiment 2, we aimed to further investigate whether the choice of pronoun affects mental simulations of perspective while comprehending narratives. Using a SPV paradigm, participants read sentences that included first or third-person pronouns (you vs. he) and pictures that depicted performing actions from different perspectives (internal vs. external). Participants' accuracy scores and response time were recorded. Although we employed an optimal design, replicating the materials and procedures used in Sato et al. (2013) and a large sample size, Experiment 2 did not replicate the personalisation effects seen in previous studies. Sato et al. found that participants were faster responding to internal images when the preceding sentence included the pronoun "you", but were faster responding to external images when the preceding sentence included the pronoun "he". Their results were in line with Brunyé et al.'s original finding (2009), however they conflict with the results reported in Experiments 1 and 2 here. Specifically, in Experiment 2, participants' response times were not affected by pronoun or perspective, which suggests that comprehension was not facilitated by personalisation, and that internal/external simulations of events are not consistently activated by first and third person pronouns.

It is possible that personalisation effects are weak, since only SPV paradigm are used here, and that personalisation has a more robust effect on memory processes (as reported in Berry et al., 2003; Cunningham et al., 2008). Thus, in Experiment 3 we examined evidence for a personalisation effect using a memory task. Ditman et al. (2010) used a memory task to test the hypothesis that personal pronouns prompt individuals to mentally simulate events from an actor's perspective, leading to better recall of actions (i.e. the enactment effect; Ditman, Brunyé, Mahoney, & Taylor, 2010; Engelkamp & Krumnacker, 1980). Results supported this claim by showing that participants had a better memory for action items that were presented through the pronoun 'you'. This further supports the role of motor simulation in memory for text, which has been preciously shown by Engelkamp and Krumnacke (1980). Engelkamp demonstrated that action verbs were better remembered when the learning phase involved simulating the motor processes, i.e. "acting out the action", compared to simply encoding them verbally. This effect was present when participants performed the action on a real object or even when they imagined doing it. In general, this enhanced memory effect for motor simulation effect has been associated with richer mental representations of those events/actions when motor and perceptual processes are involved (Engelkamp, 1998; Nilsson, 2000).

2.3. Experiment 3

In Experiment 3, we tested the prediction that presenting sentences of different events through pronoun 'you', compared to pronouns 'he' and 'I', will lead to a better memory for those events, by conducting a study similar to Ditman et al.'s study (2010). Ditman et al. tested the effects of personalisation on memory by presenting participants with short narratives that described motor actions from different perspectives (using the pronouns "I", "you", or "he/she"), then later testing their memory for the described events. They found that participants were faster and had higher sensitivity in recalling actions when they had been presented with the pronoun "you" compared to when they had been presented with the pronouns, "I" or "he". This finding was observed following both a short and longer delay between encoding and test (10-minute vs. 3-day delay). In addition, participants had a better memory for action items (e.g. “slicing the tomato”) compared to descriptive items (e.g., “a 22-year old deli employee”), regardless of perspective. In Experiment 3, we aimed to replicate Ditman et al.’s findings (2010) using the same memory paradigm.

2.3.1. Methods

2.3.1.1. Participants

Forty-one undergraduate students (comparable to Ditman et al.’s sample size, n=36) at the University of Kent were initially recruited to complete this study (36 females and 5 males; M age= 20.33, SD age= 4.38, age range 18-39). The data from two participant was discarded as they did not return to complete the memory task. Participants were recruited through the School of Psychology’s online Research Participation Scheme (RPS) in return for course credits. Participants were native speakers of English and they did not have any language or neurodevelopmental disorders. Note that Ditman et al. (2010) employed a mixed design, with time delay for the recognition task manipulated between-subjects; one group completed the recognition task after the 10 minutes delay and the other group completed it after a 3 days delay. In this experiment “delay” was manipulated within-subjects to increase the power.

2.3.1.2. Materials and Design

This study employed a 3 x 2 x 2 repeated-measures design, including pronoun (I vs. you vs. he), delay (10 minutes vs. 3 days delay) and items (descriptive vs. action items) as within-subjects variables. Participants’ accuracy, false alarms (i.e. indicating the new items were previously presented mistakenly), and response times were recorded for analysis.

Descriptive sentences: Thirty-six sets of sentences (each set included 3 sentences), were used as experimental items, taken from Sato et al.'s study (2013; similar to those used in Ditman et al.'s study). These were the same sentences as used in Experiment 2. There were three versions of each set based on the pronoun included in the sentences ("I" vs. "you" vs. "he"). Similar to Ditman et al.'s study no filler or practice items were included.

Recognition task: Two yes-no recognition tests were created, one to be used after the 10-minute delay and the other to be used after the 3-day delay. Each recognition test included 18 of the original experimental scenarios, including 18 descriptive test items and 18 action items of same scenarios in each test (6 items for each pronoun). The descriptive and action items were extracted from the first and the third sentences of the scenarios, respectively (e.g. "an 18-year old librarian" was used as a descriptive test item, and "checking the due dates" was used as the action test item).The order in which these two tests were administered was counterbalanced across participants. As in Ditman's study, we also created nine partially old action items, using two different combinations: old verb + new object, and new verb + old object to be used as filler items. The old verbs/objects were adopted from 18 items that were not included in the test items (i.e. we used 18/36 items as experimental items in test 1, then the old phrases were adopted from the other unused items). Furthermore, 18 novel descriptive items and 9 new action items phrases were also created to be used as extra descriptive and action filler items. Hence in each test there were 36 items that required a "yes" response and 36 that required a "no" response.

2.3.1.3. Procedure

Participants were randomly assigned to one the three lists to complete the reading task, so that each participant saw each of the 36 experimental items once, but only in one pronoun condition. The sentences in each list were equally distributed across each pronoun (6 experimental items in each pronoun condition), and items were presented in a random order. Participants were instructed to read each sentence carefully, and to try to remember them as their memory for the sentences would be tested later. First a fixation cross appeared on the screen for 500ms, then the three sentences for each item were presented one after each other for a fixed duration. The first and second sentences were on the screen for 3 seconds and the last sentence was presented for 2 seconds (as in Ditman’s study).

Following the reading task, participants completed a classic Operation Span task (OSPAN), which provided a 10-minute delay before the first recognition task. The same participants returned to the lab to complete the second recognition task 3 days later. Each recognition task included a different set of 72 single sentences- 36 from the original set, and 36 new or partially new. Participants were instructed to press “y” on the keyboard if they thought that the item on the screen was presented previously, and “n” if they thought the presented item had not been presented before. Participants were given 5 seconds to respond before the task automatically proceeded to the next item. We note some minor differences in the number of items in our experiment *vs.* Ditman’s memory experiment. Ditman and colleagues used 24 items in their reading task and 16 experimental items in the recognition tasks, meaning that the number of items in each pronoun condition in the recognition task was unbalanced. We chose to increase the number items included in each of the recognition task to 36 to ensure that equal number of items were tested in each pronoun condition.

2.3.2. Results

A 3 (pronoun: “I” *vs.* “you” *vs.* “he/she”) x 2 (time: 10 minutes delay *vs.* 3 days delay) x 2 (type: descriptive items *vs.* actions items) repeated measures ANOVA was used to analyse sensitivity (d′) and response times in the recognition task. Ditman et al. (2010) ran a series of one-way repeated measures ANOVAs to test the effect of pronoun on recognition sensitivity (d’) and reaction times, separately for descriptive and action items, and at each time delay. This analysis approach therefore cannot determine whether pronoun effects differ between descriptive/action items, or change at different delay periods. Our omnibus 3 x 2 x 2 repeated-measures ANOVA provides a more rigorous approach to testing these effects, and manipulating delay within-subjects increases the study’s power.

2.3.2.1. Sensitivity (d')

Sensitivity is defined as an individual’s ability to detect a signal in noise/another signal (Brophy, 1986). In the memory literature, d′ is calculated by calculating the z-scores of proportion hits and false alarms, then subtracting z(fa) from z(hit). More positive d’ values indicate greater sensitivity to the signal. Our analysis revealed a significant main effect of type [$F(1, 38) = 4.70$, $p= 0.037$, $\eta p2 = 0.11$], with participants showing more sensitivity for descriptive items (*M*=-0.04, *SE*= 0.11) compared to action items (*M*=-0.28, *SE*= 0.09). There was also a main effect of pronoun [$F(2, 76) = 3.36$, $p= 0.040$, $\eta p2 = 0.08$], reflecting marginally more recognition sensitivity for items presented with the pronoun “I” (*M*=-0.01, *SE*= 0.13) compared to “he/she” (*M*=-0.40, *SE*= 0.13; *p*= 0.059). The main effect of time was not significant (F= 2.64, *p*= 0.113).

The interaction between type and time was statistically significant [F(1, 38) = 8.06, *p*= .007, ηp2 = 0.18], with participants showing more sensitivity towards action items at time 1 (*M*=-0.00002, *SE*= 0.11) compared to time 2 (*M*=-0.53, *SE*= 0.10; *p*= 0.006), but no difference in sensitivity between time 1 and 2 for descriptive items (*MD*= -0.08, *p*= .0614). The interaction between type and pronoun was also significant [F(2, 76) =7.52, *p*= 0.001, ηp2 = 0.17], revealing that participants were more sensitive for action items that had previously been paired with pronouns “I” (*M*=0.00, *SE*= 0.16) and “you” (*M*=-0.06, *SE*= 0.13), compared to pronoun “he/she” (*M*=-0.79, *SE*= 0.13, *p*< 0.001) for both comparisons). Pronoun did not influence sensitivity for descriptive items (all *MD*s < -0.11, all *p*s > 0.570). The interaction between time and pronoun was also significant [F(2, 76) = 7.61, *p*= 0.001, ηp2 = 0.17], showing that at time 2 participants showed more sensitivity for items that had previously been paired with pronouns “I” (*M*=-0.0006, *SE*= 0.14) and “you” (*M*=-0.00003, *SE*= 0.13), compared to pronoun “he” (*M*=-0.79, *SE*= 0.15, *p*< 0.001 for both comparisons). Finally, the 3-way interaction between type x time x pronoun was significant [F(2, 76) = 7.61, *p*= 0.001, ηp2 = 0.17]. Follow up Bonferroni-adjusted comparisons revealed that at time 2 participants were more sensitive responding to action items that had previously been paired with pronouns “I” (*M*=-0.0006, *SE*= 0.19) and “you” (*M*=-0.00005, *SE*= 0.18), compared to pronoun “he/she” (*M*=-1.58, *SE*= 0.16, *p*< 0.001 for both comparisons).

Table 2.3. Means and SEs (in brackets) of sensitivity scores (d′) in each condition for Experiment 3.

Time		**Pronouns**		
	1	I	You	He
	Descriptive	-0.02 (0.24)	-0.22 (0.18)	0.00 (0.24)
Items				
	Action	-0.0003 (0.21)	-0.12 (0.20)	-0.0001(0.21)
	2	I	You	He
	Descriptive	- 0.0002 (0.18)	0.0000 (0.17)	0.0003(0.22)
Items				
	Action	0.0001 (0.18)	-0.0001 (0.19)	-1.58(0.16)

2.3.2.2. Response times

Response times were measured from the onset of the recognition cue (in milliseconds) until participants responded. Only trials in which participants correctly responded were included, and response times that were longer than (mean+ 2.5*SD) and shorter than (mean – 2.5*SD) were excluded from the analysis (outliers were calculated for each individual separately). Analyses revealed a significant main effect of pronoun [F (2,64) = 3.81, p= 0.027, ηp2 = .11], as participants were significantly faster responding to items that had previously been paired with "I" (M= 1431.55, SE= 42.03), compared to items that had previously been paired with "he/she" (M=1522.98, SE= 47.31, p= 0.031). Neither the main effect of type (F=), or time (F=1.40, p= 0.245), or any of the interactions was significant (all Fs < 1.92, ps > 0.175).

Table 2.4. Means and SEs (in brackets) of response time (ms) in each condition for Experiment 3.

Time		**Pronouns**		
1		I	You	He
Items	Descriptive	1483.71 (69.34)	1590.66 (73.36)	1612.66 (75.86)
	Action	1353.11 (63.74)	1455.70 (66.22)	1494.70 (80.55)
2		I	You	He
Items	Descriptive	1431.32 (74.90)	1423.63 (66.81)	1450.57 (59.22)
	Action	1426.54 (68.01)	1407.11 (54.59)	1427.78 (78.02)

2.3.3. Summary

In Experiment 3, we aimed to investigate that whether using personalised pronouns would enhance participants' mental simulations of events (and hence make the event more salient) relative to third person pronouns, using a task that does not necessarily promote mental imagery. Similar to Ditman et al.'s study (2010), participants read short scenarios that described a protagonist performing an action, and included the pronouns "I", "you", "he/she". Participants' memory for the descriptions and actions was tested following a 10-minute and a 3-day delay. Results were partially inline with the findings from Ditman el al.'s study (2010), by showing that after a 3-day delay participants had better memory for action items that had previously been presented with the personalised pronouns “you” and “I”, compared to those that were presented with the pronoun ”he/she”. However, the current study found stronger evidence for enhanced processing following the pronoun “I”, while Ditman et al. found stronger evidence for enhanced processing following the pronoun “you”. Our results are in line with Brunyé et al.’s (2009) Experiment 1, in which participants were faster responding to internal images when action sentences were presented with the pronoun “I”. These effects highlight inconsistencies in the literature regarding the degree to which personal pronouns “you” or “I” prompt readers to experience events from an internal (vs. external) perspective. Finally, our results showed that participants were more sensitive remembering descriptive items compared to action items, which directly contradicts the enactment effect, suggested by Engelkamp and Krumnacker (1980).

2.4. Discussion

In this chapter, I have reported three experiments that sought to investigate whether different pronouns modulate the perspective (internal vs. external) that individuals simulate when they process language, and whether personalised language enriches the specificity of representations. Experiments 1 and 2 applied the SPV paradigm to investigate this topic. Participants were either presented with single sentences or 3-sentence scenarios, in which a protagonist was performing an action. The subject of the verb was either presented with a personal pronoun, such as “you” and “I”, or an external pronoun, such as “he/she”. In Experiments 1 and 2 we did not find any evidence that using personal pronouns encouraged participants to simulate the described actions from an internal perspective. This contrasts with the findings from Brunyé et al. (2009) and Sato et al. (2013), whose methods we replicated.

Nevertheless, we did find some evidence that a third person pronoun ("he/she") activates an external simulation of events; in Experiment 1 participants were faster responding to external pictures when the pronouns "he/she" were used. Participants were also more accurate overall responding to pictures from an external perspective. Importantly, we failed to find evidence for internal language simulation in Experiments 1 and 2 despite using the same basic designs as previous studies that have reported these personalisation effects. In fact, in Experiment 2 we used the materials and methods from Sato et al. (2013) to ensure a close replication was conducted, thus ensuring that any differences could not be due to methodological differences between our study and the original work. Finally, in Experiment 3 we tested for effects of personalisation in a memory task, to explore whether perspective effects can be reliably observed in a different domain. Here, we found some evidence for enhanced processing of personalised language, as participants better remembered items that had previously been presented with the pronoun "I", and had a better memory for action items following a 3-day break when pronouns 'you' and 'I' were used. These results were partially in line with the findings by Ditman et al. (2010).

Given the mixed findings from Experiments 1 and 2, we explored some of the individual differences in perspective simulations by calculating the percentage of participants who demonstrated the expected pattern in the reaction times (i.e. as reported in Brunyé et al., 2009). In Experiment 1, 58% of participants were faster responding to the image with an internal perspective when the pronoun "I" was used, and this was dropped to 45% when the pronoun "you" was used. Also, 61% of participants were faster responding to the external perspective images when "he/she" was used. In Experiment 2, only 45% of participants were faster responding to the internal perspective images when the pronoun “I” was used, and 64% of participants were faster responding to the external items faster when “he/she” was used. We found that only 29% of participants in Experiment 2, and 19% of participants in Experiment 1 showed the expected reaction time pattern in all conditions. Clearly then, the effects of pronoun on language simulations are subject to a great deal of individual variance.

Indeed, even the authors of the original study have struggled to replicate their own work, and have questioned the generalisability of the paradigm. The author provided us with results of 2 unpublished experiments, in which they only partially replicated their original effects (only for the pronouns ‘you’ and ‘he and partially for the pronoun ‘I’), observing different effect sizes, compared to those obtained in the original study (Brunyé, Taylor, Gardony, Ditman, & Giles, 2013). More importantly, they observed that only one third of their sample (about 33%) showed the expected pattern in all conditions, and about 12% of their sample showed the patterns in the opposite direction in all conditions. In another published study Brunyé et al. (2016) managed to replicate their original 2009 findings, however, they had to use a very large sample and include more items to replicate their original findings (N=263 vs. 48 used in the original study; Brunyé et al., 2016). Based on the results of our and others’ replication experiments, it can be concluded that perspective does not universally influence simulations of language or facilitate memory for language, or if it does, the effects are so small that they cannot be reliably detected even using rigorous experimental designs and robust sample sizes.

Recent evidence suggests that mental simulation during reading comprehension depends upon various individual differences and situational factors, such as empathy, imagination, etc. (Brunyé et al., 2016; Hartung et al., 2017;

Komeda et al., 2013; Ruby, & Decety, 2001). For example, Vukovic and William (2015) categorised their participants into two groups according to the extent with which they used allocentric vs. egocentric references in a virtual navigation task. They found that when the pronoun "you" was used only participants in the egocentric group simulated the internal perspective described in the sentences. Brunyé et al. (2016) also demonstrated that individuals who had a higher tendency to invest in reading text emotionally (i.e. high empathic engagement) were more likely to adopt the perspective that was described in the text (i.e. showing different cognitive processing styles).

In general, the results of these experiments suggest that SPV paradigm may not be a powerful measure to detect the perceptual processes of language processing. Ostarek and Huettig (2019) suggested that by relying on accuracy scores and reaction times (i.e. using SPV paradigms), we may fail to capture the interactions that exist between the embodied and amodal accounts. First, since literature demonstrates that individuals apply different cognitive styles to adopt perspective in text, using novel neuro imaging techniques could help us to gain a better understanding of the mechanisms that underlie these processes. Second, most of the studies that found this personalisation effect used small number of trials. For example, in Brunye's study (2009) out of 24 trials, six were fillers (i.e. in which the events in the sentences and images did not match), and six were foils (i.e. the actions were not being performed). Thus, only 12 trials were included in the analysis for each participant. Future studies should take these limitations into account when designing experiments to study this topic in future.

In conclusion, our results seem to support the pluralistic theory of embodiment, suggesting that depending on the nature of the task, natural language processing involves both embodied and amodal/abstract processes. For example, we found evidence that representing the perspective depicted in a text is not necessarily taken into account during comprehension, unless the task instructions/requirements specify otherwise. Hence, future research should more focus on how these two processes interact to facilitate comprehension (Dove, 2011). We also found that individual preferences in perspective taking influence the way in which individuals mentally simulate the text and to what extent they do it automatically. We believe these are the avenues that future research should investigate using more sensitive and informative measures. Considering the findings of experiments 1,2, and 3, I decided not to investigate this topic in autism and aimed to investigate the role of perspective and non-linguistic context on language processing with a new approach, by focusing more on the social aspect of perspective taking in language, using sensitive and online measures. In the next experimental chapter, using ERPs and eye-tracking, I aimed to study whether autistic and non-autistic individuals use social stereotypes to take the perspective of the speaker to facilitate the online language comprehension.

Chapter 3: Autistic adults anticipate and integrate meaning based on the speaker's voice: Evidence from eye-tracking and event-related potentials

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Autistic adults anticipate and integrate meaning based on the speaker's voice: Evidence from eye-tracking and event-related potentials

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Author note: All analysis procedures were pre-registered, and the full experimental materials, datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/7hna3/).

3.1. Abstract

Typically developing (TD) individuals rapidly integrate information about a speaker and their intended meaning while processing sentences online. We examined whether the same processes are activated in autistic adults, and tested their timecourse in two pre-registered experiments. Experiment 4 employed the visual world paradigm. Participants listened to sentences where the speaker's voice and message were either consistent or inconsistent (e.g. "When we go shopping, I usually look for my favourite wine", spoken by an adult or a child), and concurrently viewed visual scenes including consistent and inconsistent objects (e.g. wine and sweets). All participants were slower to select the mentioned object in the inconsistent condition. Importantly, eye movements showed a visual bias towards the voice-consistent object, well before hearing the disambiguating word, showing that autistic adults rapidly use the speaker's voice to anticipate the intended meaning. However, this target bias emerged earlier in the TD group compared to the autism group (2240ms *vs* 1800ms before disambiguation). Experiment 5 recorded ERPs to explore speaker-meaning integration processes. Participants listened to sentences as described above, and ERPs were time-locked to the onset of the target word. A control condition included a semantic anomaly. Results revealed an enhanced N400 for inconsistent speaker-meaning sentences that was comparable to that elicited by anomalous sentences, in both groups. Overall, contrary to research that has characterised autism in terms of a local processing bias and pragmatic dysfunction, autistic people were unimpaired at integrating multiple modalities of linguistic information, and were comparably sensitive to speaker-meaning inconsistency effects.

Keywords: spoken language comprehension, pragmatics, visual world paradigm, event related brain potentials, autism.

The process of inferring meaning from language is strongly influenced by the wider context, including verbal frame, tone of voice, gestures, and body language, and therefore falls within the pragmatics domain of language processing (Martin & McDonald, 2003). Pragmatic language use has recently been conceptualised within an extended account of situated language processing, known as the 'social Coordinated Interplay Account' (sCIA; Münster & Knoeferle, 2018). This account proposes that characteristics of both the comprehender and speaker, including their mood, education level, and social stereotypes, are taken into account online when interpreting language (Rodríguez, Burigo, & Knoeferle, 2016; Van Berkum, De Goede, Van Alphen, Mulder, & Kerstholt, 2013; Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008;). Hence, the social context is integrated with linguistic input in real-time when we process language. A much debated question remains *when* these characteristics (context dependent) and the sentence's message (i.e. meaning of individual words, context free) are integrated to extract meaning, and which cognitive and social mechanisms underpin these processes.

Early research in this area postulated that individuals first extract the sentence's message using syntax and semantics, and only refer to pragmatics to integrate the speaker's identity at a later stage of processing (Cutler & Clifton 1999; Lattner & Friederici 2003; Osterhout, Bersick, & McLaughlin, 1997). For example, Lattner and Friederici (2003) recorded event related brain potentials (ERPs) while participants listened to sentences in which the gender of the speaker either matched or mismatched the meaning of the sentence in its usual/prototypical context (e.g. "I like to wear lipstick" spoken to by a female or male). They observed a posterior P600 effect when the speaker gender and sentence meaning mismatched. This posterior P600 effect has been interpreted as a marker for the detection of pragmatic violations (i.e. reintegrating information in the presence of an inconsistency between pragmatics and meaning inferences; Osterhout, et al., 1997; Spotorno, Cheylus, Van Der Henst, & Noveck, 2013), and is distinct from the more widespread centrally distributed P600 component that is typically elicited by syntactic violations (Gouvea, Phillips, Kazanina, & Poeppel, 2010). Indeed, Lattner et al. associated this late posterior positivity (in the absence of any earlier effects in the N400 range) with participants using pragmatics at a later stage to integrate the speaker-related information (i.e. after processing the sentence's message), and thus concluded that it supports the two-step account. However, these conclusions are somewhat limited by design features of the task, including an absence of filler sentences with syntactic violations, which could have provided a baseline measure of a syntactic P600 to contrast with the pragmatic P600 effect reported here. In addition, the gender stereotype violations were always sentence-final, meaning that the speaker-meaning effects were likely to be influenced by more global 'wrap up effects' (i.e. an increase in processing time at sentence end due to semantic integration processes; Schacht, Sommer, Shmuilovich, Martíenz, & Martín-Loeches, 2014; Stowe, Kaan, Sabourin, & Taylor, 2018).

An alternative view has been proposed, which suggests that the linguistic input and context are processed in a single step ("one step model"), as a joint action (Clark, 1996; Perry, 1997). Clark proposes that the non-verbal cues provided by the linguistic context (e.g. gestures, body language etc.) are processed in parallel with the linguistic input. This one step account is supported by empirical evidence from

Van Berkum et al. (2008), who recorded ERPs while participants listened to sentences in which speaker and meaning were either consistent or inconsistent. In Van Berkum et al.'s study, speaker voices were manipulated in three ways: 1) age: child *vs*. adult (e.g. "I cannot sleep without my teddy in my arms"), 2) social class: lower *vs*. higher class accent (e.g. "I have a large tattoo on my back"), and 3) gender: male *vs*. female (e.g. "On weekends I usually go fishing by the river"). Note that critical words (underlined in the above examples) were always presented mid-sentence, which allowed sufficient time for participants to infer the speaker's characteristics, and avoided wrap-up effects. Van Berkum and colleagues examined effects on the N400 ERP component; a centroparietal negative-going deflection that is sensitive to stimulus predictability and semantic integration processes (Kutas & Hillyard, 1980; Nieuwland et al., 2018). Results revealed a larger N400 effect for inconsistent compared to consistent sentences, with effects emerging as early as 200ms after the onset of the critical word, thus showing that speaker-related information is integrated at an early stage. These findings therefore support the one-step model of language processing, by demonstrating that interpretation of the sentence meaning is influenced concurrently by inferences about the speaker characteristics and the explicit message (i.e. 'who is saying what').

The rapid influence of social pragmatic information on meaning was subsequently replicated by Van den Brink and colleagues (2010), using ERPs. Importantly, Van den Brink et al. revealed that social information processing was enhanced among people who self-reported high levels of empathy, using the Empathizing Questionnaire (Baron-Cohen & Wheelwright, 2004). In contrast, people who self-reported low levels of empathy were consistently impaired in using information about social stereotypes during sentence comprehension. This pattern is consistent with previous research showing that high empathizers are better at predicting other people's actions and responding to them appropriately (Saxe & Baron-Cohen, 2006). Moreover, it suggests that pragmatic processing can be influenced by individual preferences for bottom-up (i.e. language first) or top-down (i.e. rapid integration of voice-based information) language processing.

All of the issues discussed so far are relevant for our understanding of autism. Autism spectrum is a developmental disorder, diagnosed on the basis of behavioural difficulties in social communication, and restricted and repetitive behaviours/interests (American Psychiatric Association, 2013; Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Shah, & Frith, 1993). Some researchers have proposed that the ability to empathise with others is impaired among autistic people (Baron-Cohen & Wheelwright, 2004), however this finding has been challenged more recently by evidence that the ability to deploy empathising abilities depends on the context. Thus, autistic people do not lack empathy but they may experience a specific difficulty empathising with TD individuals (and vice versa), since the two groups have different world experiences (Milton, Heasman, & Sheppard, 2018; Nicolaidis, Milton, Sasson, Sheppard, & Yergeau, 2018).

Importantly, communication difficulties in autism are separable from basic language impairments; semantic language comprehension and syntactic preferences seem to be relatively spared among high functioning autistic individuals (e.g. Allen, Haywood, Rajedran, & Branigan, 2011; Hopkins, Yuill, & Keller, 2016; Howard, Liversedge, & Benson, 2017a; Tager-Flusberg & Joseph, 2003). However, some studies have shown that even when structural language skills are intact autistic people show deficits in processing linguistic information *in context* (i.e. successfully extracting the intended meaning), including difficulty using the sentence context to distinguish homographs (e.g. pronouncing *tear* in, “In her eye/dress there was a big tear”, Frith, & Snowling, 1983) or process non-literal utterances (e.g. “He drew a gun”, where the verb could mean drawing or pulling out, Jolliffe & Baron-Cohen, 1999; see also Connolly, 2001; Deliens, Papastamou, Ruytenbeek, Geelhand, & Kissine, 2018; Vulchanova, Saldaña, Chahboun, & Vulchanov, 2015). The validity and generalisability of these context impairments, however, have been questioned in recent years (e.g. Brock & Bzishvili, 2013; Brock & Caruana, 2014; Hahn, Snedeker, & Rabagliati, 2015). Moreover, eye-tracking research has revealed that autistic adults are delayed relative to age and IQ-matched TD peers in detecting passage level anomalies in text (i.e. where global coherence is required; Au-Yeung, Kaakinen, Liversedge, & Benson, 2018), and in detecting implausible words in a sentence (Howard, Liversedge, & Benson, 2017b). These findings suggest that subtle differences may exist in the speed with which context is accessed and influences language processing in autism (c.f. Black, Barzy, Williams, & Ferguson, 2019; Black, Williams, & Ferguson, 2018; Ferguson, Black, & Williams, 2019).

Traditionally, these pragmatic deficits have been linked to general difficulties integrating information in context (known as ‘weak central coherence’, WCC; Booth, & Happé, 2010; Frith, 1989; Martin, & McDonald, 2003;), given that autistic people tend to show a local, rather than global, processing bias (Frith, 1989; Frith & Happé, 1994; Happé & Frith, 2006). In turn, atypical attention distribution in autism (i.e. allocating attention to details and ignoring the context) has been attributed to impaired meta-learning abilities (known as the ‘predictive coding theory of autism’ or the ‘Bayesian brain’; Van Boxtel, & Lu, 2013; Van de Cruys, Evers, Van der Hallen, Van Eylen, Boets, de-Wit, & Wagemans, 2014), which disrupts the ability to distinguish between important and less important prediction errors. These weaker priors mean that autistic individuals struggle to contextualise sensory input and make predictions based on experience, which is likely to affect many aspects of cognition, including language, memory, emotions, and motor skills (Pellicano & Burr, 2012). These weaker expectations of how people behave therefore mean that autistic people find it harder to process social information during communication, and are likely to show delays generating appropriate responses. Despite these converging accounts, there is little agreement on how a detail-focused cognitive style and weaker predictive processing style might influence the quality of social interactions. This raises the question of whether the mechanisms involved in *integrating* social pragmatic information and language meaning are disrupted among autistic individuals who experience impaired use of context and atypical social inferencing. This is an important topic to investigate, because as well as further informing theoretical models of pragmatic language comprehension and shedding light on the nature of these social impairments, it has the potential to help practitioners develop specific interventions or learning shortcuts to improve the quality of social interactions in autism.

In this paper, we present two fully pre-registered experiments that used eye-tracking (Experiment 4) and ERP (Experiment 5) methods to investigate whether and how real-time pragmatic processing of spoken language is affected when global coherence and social abilities are compromised. Specifically, we tested whether autistic adults differ significantly from matched neurotypical controls in the timecourse with which they anticipate meaning based on a speaker's characteristics (i.e. their age, gender or social status), and whether they manifest equivalent disruptions during language integration when speaker and meaning information are inconsistent.

Experiment 4 examined the timecourse with which listeners *predict* meaning based on characteristics inferred from the speaker's voice. We used the classic visual world paradigm to address this question by recording participants' eye movements around a visual scene that contained images depicting objects/events that were consistent or inconsistent with the speaker's voice (Cooper, 1974; Tanenhaus Spivey-Knowlton, Eberhard, & Sedivy, 1995). The visual world paradigm has been used extensively in psycholinguistic research to show that participants incorporate cues from syntax, semantics and world knowledge to constrain the available set of objects, and move their eyes to an appropriate visual object *before* it has been mentioned in the audio (e.g. Altmann & Kamide, 2007, 2009; Kamide, Lindsay, Scheepers, & Kukona, 2016). For example, it has been shown that participants are more likely to look at an empty glass of wine compared to a full glass of beer when hearing the sentence "the man has drunk all of…", and vice versa for "the man will drink all of …" (Altmann & Kamide, 2007). This paradigm therefore provides a valuable implicit measure of expectation in real-time, though it has never before been used to examine the timecourse with which listeners infer meaning from a speaker's voice characteristics. In the current study, we tested whether participants' predictive eye movements towards visual objects (e.g. a shaver *vs.* car) were modulated by inferences from the speaker's voice (e.g. whether an adult *vs.* child said, "On my last birthday, I got an expensive electric …"). This paradigm enabled us to examine for the first time whether and how autistic adults implicitly integrate pragmatic cues to predict meaning, and how these processes compare to those engaged by age, IQ and gender matched TD adults. Participants' explicit ability to infer meaning from a speaker's voice was measured using the 'Reading the Mind in the Voice' task (Golan, Baron-Cohen, Hill, & Rutherford, 2007; Rutherford, Baron-

Cohen, & Wheelwright, 2002), and their local/global processing bias was measured using a sentence completion task (Booth & Happé, 2010).

Experiment 5 sought to explore the timecourse with which listeners *integrate* semantic and pragmatic cues, and respond to inconsistencies in speaker and meaning. To this end, we replicated Van Berkum et al.'s (2008) study, using ERPs to compare the brain's electrophysiological responses to words that were consistent or inconsistent with characteristics inferred from the speaker's voice (e.g. "I cannot sleep without my <u>teddy</u> in my arms", spoken by a child or an adult), among adult participants with and without autism. In addition, we extended the paradigm to include a semantic anomaly condition using the same content (e.g. "I cannot sleep without my <u>pizza</u> in my arms"), that provided a baseline measure of anomaly detection N400 responses in each participant group. The addition of this semantic anomaly condition serves to overcome the possible limitation of Van Berkum et al.'s study, which tested the N400 effect to semantic anomalies in a completely different set of sentences.

First, if the linguistic input and context are processed in a single parallel step, we expected TD participants in Experiment 4 to initiate anticipatory eye movements towards the image that was consistent with the speaker's voice long before the disambiguating target word was uttered (e.g. shaver/car). In Experiment 5, we predicted an enhanced N400 effect for inconsistent sentences relative to consistent ones, which would be comparable in timecourse to the N400 elicited by semantically anomalous sentences. In contrast, a two-step account would predict that effects of pragmatic fit would be delayed, as lexical-semantic fit would be prioritised in the early stages in processing.

Second, we considered how these processes may be influenced among autistic people, and compared predictions for accounts that characterise autistic people as having a general deficit in contextual integration (e.g. Behrmann, Thomas, & Humphreys, 2006; Happé, & Frith, 2006; Koldewyn, Jiang, Weigelt, & Kanwisher, 2013), with the predictions of accounts that imply global integration ability is not universally impaired in autism (e.g. Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Plaisted, Dobler, Bell, & Davis, 2006; Van der Hallen, Evers, Brewaeys, Van den Noortgate, & Wagemans, 2015; following the results of Black et al., 2018, 2019; Ferguson et al., 2019). Based on the former, we predicted that in Experiment 4 autistic individuals would be slower than TD individuals to direct anticipatory gaze to the speaker-relevant image, and would experience greater interference from the semantic competitor (i.e. a weaker target bias). In Experiment 5, we predicted that the autism group would show a delayed, reduced or absent N400 response when integrating inconsistent speaker-meaning information. Alternatively, if pragmatic processing is largely spared in autism (as it appears to be for semantic processing), then no between-group differences in the anticipation or integration of social pragmatic meaning should emerge.

3.2. Experiment 4

3.2.1. Methods

All methodological procedures were pre-registered on the Open Science Framework (OSF) web pages (see https://osf.io/7hna3/).

3.2.1.1. Participants

Participants, including those with and without autism were recruited using the Autism Research at Kent (ARK) database. Participants on the database were initially recruited from a community sample in the areas of Kent, Essex and London in the U.K., using a variety of recruitment strategies (e.g., newspaper adverts, contacting local groups, autism support groups and word-of-mouth). We deliberately avoided using university students to minimise differences in socioeconomic status between the groups. A total of fifty adult participants were initially recruited, but two were excluded from both experiments: one due to technical errors during EEG recording, and one due to excessive noise during EEG recording (i.e. >25% data loss). Hence, both Experiments 1 and 2 included 24 autistic adults and 24 TD adults, which is in accordance with our pre-registered sample size. These sample sizes were chosen a-priori based on the sample size used in Van Berkum et al.'s study (2008; N = 24), and to be comparable or even exceed the sample sizes used in previous research that has examined eye movements in autistic and TD adults (e.g. Au-Yeung et al., 2014, 2018; Black et al., 2018; 2019; Brock, Norbury, Einav, & Nation, 2008; Ferguson et al., 2019; Howard et al., 2017ab). Post-hoc calculations of power were conducted given the current sample size using the simr package in R (Green & MacLeod, 2016), and returned an estimated power of 100% with the significance level of α=.05 on 80% of occasions (as suggested by Cohen, 1988) for Experiment 4.

Groups were matched on age, verbal IQ[3] and gender (as measured by the Wechsler Abbreviated Scale of Intelligence; WASI; Wechsler, 1999; see Table 3.1.

[3] Note that the autistic group scored significantly higher on PIQ. Therefore, in addition to the full-sample analyses, we ran analyses among subsamples of autistic and TD participants that were matched for PIQ (by excluding one participant from each group with the highest and lowest PIQ scores). Crucially, none of the statistical results from the experimental task changed substantively with this smaller matched sample (i.e. no *p* value changed from significant to non-significant or vice versa).

for demographic information), were native English speakers, and did not have a diagnosis of dyslexia or reading comprehension impairment. Participants in the TD group did not report any current psychiatric diagnoses. All participants completed the Autism-spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) to measure self-reported autistic traits.

Table 3.1. Demographic information (means and std. errors) of participants in each group, where * $p<.05$, ** $p<.01$, *** $p<.001$.

	Autistic (n=24)	Typically developing (n=24)	*t*-value	*p*-value	Cohen's d
Sex (m:f)	18:6	18:6	-	-	-
Age (years)	32.58 (2.23)	31.75 (2.21)	.27	.792	.08
Verbal IQ	105.46 (2.51)	101.46 (1.80)	1.29	.202	.37
Performance IQ	112.75 (3.84)	102.29 (2.36)	2.32	.025 *	.67
Total AQ	30.92 (1.75)	18.05 (1.64)	5.35	<.001 ***	1.58
ADOS2 Module4	7.79 (0.99)	-	-	-	-

In accordance with DSM-IV or 5, all autistic participants had a formal diagnosis of Autistic Disorder, Asperger's Syndrome, or Pervasive Developmental Disorder Not-Otherwise Specified (American Psychiatric Association, 2013). To assess the current autistic characteristics, all the autistic participants were also assessed on module 4 of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) by a trained, research-reliable researcher, and videos were double coded to ensure reliability of scoring (see Table 3.1.; inter-rater reliability was found to be excellent with intraclass correlation of .89). Eleven individuals in the autistic group scored higher than 7 on the ADOS (i.e. the cut off score).

3.2.2. Materials

3.2.2.1. Eye-tracking task

Twenty-four experimental sentences were created based on those used in Van Berkum et al. (2008). Each item described a person's preferences, or activities. The final word in each sentence was manipulated across two conditions so that the lexical content either matched a specific speaker's stereotypical characteristics or not (speaker-consistent *vs* speaker-inconsistent). For example, the sentence "When we go shopping, I usually look for my favourite sweets" is consistent with social stereotypes for a child, but the sentence "When we go shopping, I usually look for my favourite wine" is inconsistent with expectations for a child. Each experimental sentence was recorded by two contrasting speakers, resulting in four versions of each item, with social stereotypes manipulated in three ways- 1) Age: child *vs* adult (see above example), 2) Class: higher *vs* lower class accent (e.g. "I never smoke inside, because my wife doesn't like the smell of cigars/rollies), 3) Gender: female *vs* male (e.g. "Before starting my new job, I need to buy a new skirt/tie"). Twenty-four filler sentences were also included (e.g. "It was Valentine's Day so I bought her a bunch of red roses"), which didn't include any inconsistent content.

Ten different speakers were recruited to record the sentences. One female and one male adult speaker read eight items in the 'gender' category (four sentences per item). Two children (one female and one male, aged 6 and 8 respectively) and two adults (one female and one male) read eight items in the 'age' category. Finally, four professional actors (2 females and 2 males) were recruited from local drama groups to read eight items in typically high or low socio-economic British accents for the 'class' category. Audios were recorded in a sound proof room using a digital voice recorder. One female and one male adult speaker read the filler sentences (12 sentences each). All speakers were native speakers of English.

To verify that listeners inferred the intended social stereotypes from speaker's voices, we conducted a post-test, in which 22 TD participants (10 males, 12 females) listened to each item then used a 5-point sliding scale to rate "how normal or strange do you think it is to have the speaker say this particular thing" (1 = completely normal, 5 = very strange). Overall, inconsistent speaker-meaning combinations were rated as significantly more strange than consistent speaker-meaning combinations ($M = 2.39$ *vs* 1.76, $t(77) = 10.22$, $p < .001$). In addition, we tested the effect of consistency separately for each speaker type (i.e. age, gender and class). This analysis confirmed that inconsistent speaker-meaning combinations were rated as significantly more strange than consistent speaker-meaning combinations in all three speaker categories: Age ($t(77) = 9.09$, $p < .001$), Class ($t(77) = 2.62$, $p = .011$), and Gender ($t(77) = 8.23$, $p < .001$).

Each of the twenty-four experimental sentences was paired with an image that depicted four different objects (see open materials on OSF, https://osf.io/7hna3/). Two objects in each image were semantically relevant to the sentence (e.g. edible objects for the supermarket example). One of these was consistent with social stereotypes about the speaker (subsequently referred to as the target picture, e.g. a picture of 'sweets' when the sentence was read by a child), and the other was inconsistent with social stereotypes about the speaker (subsequently referred to as the competitor picture, e.g. a picture of 'wine' when the sentence was read by a child). The remaining two pictures depicted distractor objects that were irrelevant to the sentence content (e.g. a house, a lake). Filler items were also paired with images that included four pictures, but only one picture matched the lexical content of the sentence (e.g. red roses in the example above). Each individual picture measured 400x400 pixels, with the complete image comprising four pictures on a white background measuring 960x720 pixels, with the position of target, competitor and distractor pictures counterbalanced across items.

3.2.2.2. Revised 'Reading the Mind in the Voice' task (RMIV)

Participants' explicit recognition of meaning from voices was assessed using the RMIV task. In this task, developed by Golan et al. (2007), participants listened to 25 different excerpts of speech and had to judge how each person was feeling (only based on their voice) from a choice of four options (e.g. "angry, derogatory, resentful or nostalgic"). There was no time limit for participants to respond, although they were encouraged to respond as quickly as they could. Participant's accuracy was recorded.

3.2.2.3. Linguistic Central Coherence task

Participants' local processing bias during language processing was measured using a sentence completion task. In this task, participants were asked to complete 14 sentences that required global sentence completions. For example, the sentence fragment, "in the sea there are fish and…." could be completed with a locally biased word "chips", or with a globally biased word like "sharks" or "crabs". Participants' responses and their reaction times were recorded.

3.2.2.4. Procedure

The Psychology Research Ethics Committee at the University of Kent granted approval to conduct this study. For the eye-tracking task, participants' dominant eye was tracked with an EyeLink 1000 Plus eye-tracker and participants listened to the sentences through headphones. Head movement was minimised with the use of a fixed chin rest. Images were presented on a VDU approximately 70cm in front of the participants' eyes. Calibration was performed using a 9-point procedure. Before each trial, a central drift correction was conducted to verify the calibration accuracy. Participants were asked to listen to each sentence and look at the images, and used the mouse to click on the picture that was mentioned in the sentence as quickly as possible. Images appeared on screen 1000ms before the onset of related audio, and stayed onscreen until the participant clicked the mouse to move on. Participants' picture selection accuracy, reaction times (time-locked to the onset of the target picture), and eye-movements across the whole trial were recorded. The next trial began following a 500ms blank screen. The first two items were filler trials to ensure participants understood the task. Following presentation of these, the 24 experimental items were randomly interleaved with 22 filler items, with a break offered half way through. Participants saw each item once, in one of the four conditions. Item order and condition was randomised across four lists, and the presentation of each list was randomised among participants. Each participant completed the eye-tracking and RMIV tasks on the same day as the EEG task reported in Experiment 5. The whole testing session took about 2 hours including EEG setup and breaks.

3.2.2. Results

All analysis procedures were pre-registered, and the full experimental materials, datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/7hna3/).

3.2.2.1. RMIV task

Accuracy scores were analysed using a generalised linear mixed model, using the 'lme4' package in RStudio software Version 1.1.453 (Bates, Mächler, Bolker, & Walker, 2018; R Core Team, 2016). Group (autistic *vs* TD) was included in the model as a fixed effect and was contrast coded: (-.5 *vs* .5). We applied the maximal random effects structure, by including participants and items as random effects, and Group as a random slope on items (as suggested by Barr, Levy, Scheepers, & Tily, 2013). The analysis revealed that autistic participants were significantly less accurate at explicitly recognising speakers' emotions based on their voice compared to TD participants (M = 65% *vs* M = 70%; Est = .41, SE = .20, z = 2.07, p = .038).

3.2.2.2. Linguistic Central Coherence task

Similar to Booth and Happé (2010), a 3-point scoring system was used to analyse responses. Two points were given if participants provided a global sentence completion word/phrase within 10 seconds, and 1 point was assigned if they took longer than 10 seconds or provided no response. If they used a local sentence completion word/phrase, then 0 points were assigned. Response scores were analysed using a linear mixed model. Group (autistic *vs* TD) was included in the model as a fixed effect and was contrast coded: (-.5 *vs* .5). The maximal random effects structure included participants and items as random effects, and Group as a random slope on items. The analysis revealed no difference between groups in terms of global/local sentence completion bias (autistic *vs* TD; *M* = 1.75 *vs* *M* = 1.73; *Est.* = -.02, *SE* = .10, *t* = -.21, *p* = .832).

3.2.2.3. Eye-tracking task

Accuracy: Accuracy of selecting the mentioned picture was analysed using a generalised linear mixed model, with Group (autistic *vs* TD) and Condition (consistent *vs* inconsistent) as contrast coded fixed effects (-.5 *vs* .5). The maximal random effects structure that fit the data included participants and items as random effects, with Condition as a random slope on items and participants. Participants were highly accurate at choosing the mentioned picture (autistic *vs* TD, *M* = 97% *vs* 98%), and this did not differ between groups (*Est.* = 1.57, *z* = 0.82, *p* = .412) or conditions (*Est.* = -7.56, *z* = -1.29, *p* = .196).

Reaction Times: Only trials on which participants accurately clicked on the mentioned object were included in the analysis. In addition, response times that fell more than 2.5 standard deviations from the individual's mean reaction time were excluded from analysis. These steps removed 4.25% of the original data. Statistics were performed using a linear mixed model, including the same fixed effects structure as the accuracy analysis, and the maximal random effects structure to fit the data (Group and Condition as random slopes on items, and Condition as a random slope on participants). Mean response times per condition are shown in Figure 3.1.

Results showed that participants were faster to select the mentioned object when the speaker characteristics were consistent with the mentioned object than when the speaker characteristics were inconsistent (*M* = 1572ms *vs* 1729ms; *Est* = 158.81, *SE* = 45.81, *t* = 3.47, *p* = .002). Reaction times did not differ by Group (*Est* = -137.02, *t* = .80, *p* = .427), nor did Group modulate the effect of Consistency (*Est* = -10.77, *t* = .14, *p* = .888).

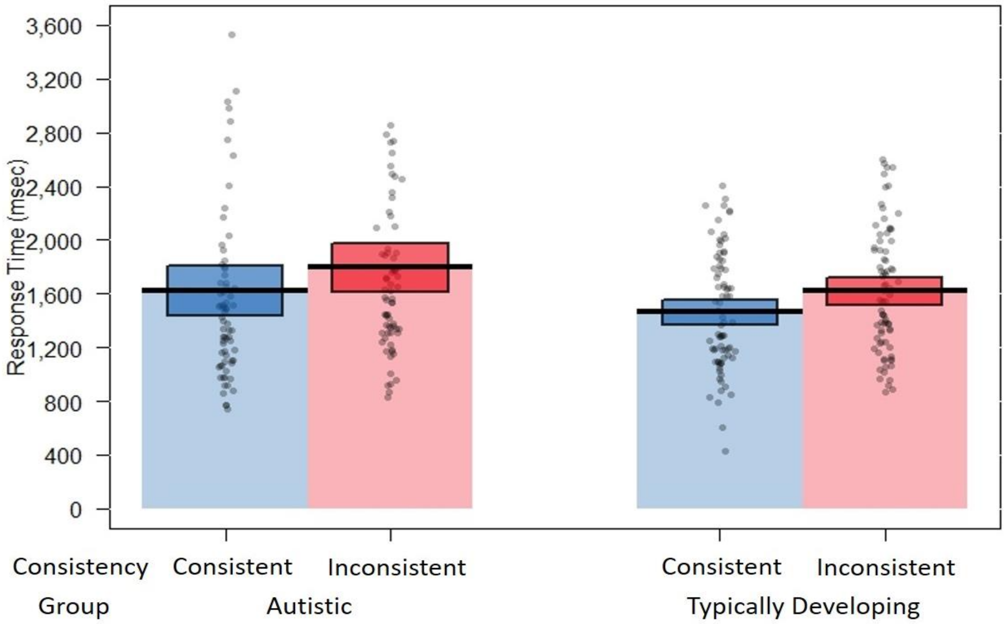


Figure 3.1. Target selection response times for each condition and group, Experiment 4, showing raw data points, a horizontal line reflecting the condition mean, and a rectangle representing the Bayesian highest density interval.

Eye Movement Data Processing: Eye movements were time-locked to the onset of the sentence-final disambiguating word (e.g. 'sweets' or 'wine'), and were analysed in two separate time periods: anticipatory period (eye movements in the 3000ms before disambiguating word onset, reflecting listeners' expectations about forthcoming language input) and integration period (eye movements in the 1000ms after disambiguating word onset, reflecting the ease with which incoming language is integrated with expectations). Four areas of interest (AOIs) were defined around the pictures of objects in each visual scene: target (the object that matched both the semantic context of the sentence and the speaker's voice), competitor (matched the semantic context but not the speaker's voice), and two distractors (did not match either semantic context or the speaker's voice).

Eye movements during the anticipation period were analysed across consistency conditions, since listeners had not yet heard the consistent/inconsistent critical word, so expectations should be solely driven by inferences from the speaker's voice. Thus, anticipatory analyses tested whether participants in each group differed in their likelihood of fixating the speaker-relevant target picture or speaker-irrelevant competitor picture, and whether these preferences emerged over a different time course for each group. To fulfil this aim, fixations during the 3000ms anticipatory period were broken down into 20ms time bins, and the spatial coordinates were mapped onto AOIs as a function of time. Visual preferences to target or competitor pictures were represented by a binary term in each 20ms time bin, where '1' indicated a fixation on the target/competitor and '0' indicated no fixation. The resulting data was analysed separately for target and competitor biases using generalised mixed models and growth curve analysis (Mirman, Dixon, & Magnuson, 2008), using the 'lme4' and 'eyetrackingR' packages in RStudio. We note that our pre-registration proposed to analyse the probability of fixating the target and competitor images as a function of time using permutation and cluster analysis, and did not specify the use of growth curve analysis. We chose to use growth curve analysis to examine anticipatory effects of linguistic context (permutation and cluster analyses were used to examine integration, as detailed below) following more recent statistical norms in the field. Fitting models to the data to test different shapes of visual bias over time allows us to capture effects of group as the sentence unfolded, while also testing for variance between and within individuals. In this study, third-degree orthogonal polynomials, incorporating intercept, linear, quadratic and cubic components, were used to model the timecourse of anticipatory bias over the 3000ms period (see Mirman et al., 2008). Thus, final models included a contrast coded fixed effect for Group (-.5 *vs* .5) alongside the time polynomials, and random effects of participants and items. The final model also included Group as a random slope within items. Resulting statistical effects are shown in Table 3.2.

Table 3.2. Statistical results from the growth curve analysis examining anticipatory fixations towards the Target and Competitor objects in Experiment 4. Ot1, ot2 and ot3 refer to linear, quadratic and cubic models of time, respectively, and * p<.05, ** p<.01, *** p<.001.

	Target			Competitor		
	Est.	*SE*	*z-value*	*Est.*	*SE*	*z-value*
Group	0.06	0.08	0.77	-0.04	0.09	-0.39
ot1	2.11	0.07	28.45 ***	1.51	0.11	13.49 ***
ot2	0.49	0.07	6.54 ***	-0.44	0.11	-3.96***
ot3	0.47	0.07	6.30 ***	-0.03	0.11	-0.24
Group*ot1	0.2	0.15	1.35	-0.96	0.15	-6.27***
Group*ot2	0.06	0.15	0.4	0.18	0.15	1.2
Group*ot3	-0.64	0.15	-4.28 ***	-0.26	0.15	-1.73

Follow-up analyses explored *whether* and *when* anticipatory biases to the target or competitor picture exceeded chance level (i.e. .25) for each group. Thus, we ran cluster-based permutation analysis by participants (Maris & Oostenveld, 2007) to compare the proportion of target or competitor fixations during the anticipatory period to chance, using the ‘eyetrackingR’ package in RStudio. First, we computed a 1-sample test statistic for each of the 20ms timebins, comparing each sample to chance (.25). Next, we clustered together adjacent timebins for which the test statistic was significant at the .05 level, and calculated a cluster-level test statistic as the sum of the test statistics for the individual timebins within a particular cluster. Finally, a simulation with 2000 randomly permuted samples was run to determine the likelihood of obtaining a significant cluster by chance. Permutation analyses included random effects for participants.

Eye movements during the integration period examined *when* participants in each group identified the consistent/inconsistent word, and how quickly they were able to switch their attention away from the target image to the competitor image in the inconsistent condition. To this end, fixations during the 1000ms integration period were broken down into 20ms time bins, and the spatial coordinates were mapped onto AOIs as a function of time. Visual preferences to target or competitor pictures were represented by a binary term in each 20ms time bin, where ‘1’ indicated a fixation on the target/competitor and ‘0’ indicated no fixation. The resulting data was analysed separately for each group, and for target and competitor biases, using a similar cluster-based permutation analysis approach to that described for the anticipation period. Crucially, here we used paired-samples t-tests to compare the proportion of target or competitor fixations in each 20ms sample between consistent and inconsistent conditions. This allowed us to identify when a significant difference in visual biases emerged between consistent and inconsistent conditions in each group. Permutation analyses included random effects for participants. Statistical effects for the permutation analyses, for both anticipatory and integration periods, are shown in Table 3.3.

Table 3.3. Statistical results from the permutation t-test analyses comparing anticipatory and integratory biases towards the Target and Competitor objects to chance in Experiment 4, where * p < .05, ** p < .01, *** p < .001.

		Target				Competitor			
		Cluster No.	Start Time	End Time	SumT	Cluster No.	Start Time	End Time	SumT
Anticipation	*Autistic*								
		1	-3000	-2940	7.13	1	-2200	-1900	8
		2	-2300	-2160	17.46	2	-1500	-1200	8.02
		3	-2100	-2080	2.03	3	-1000	-300	22.31 **
		4	-2060	-2000	6.9	4	-200	-100	2.15
		5	-1960	-1940	2.32				
		6	-1840	-1820	2.11				
		7	-1800	0	392.02 ***				
	Typically developing								
		1	-2680	-2660	2.14	1	-1700	-1500	4.11
		2	-2240	-1520	115.4 ***	2	-1100	-700	9.61
		3	-1500	-1400	10.98	3	-600	-500	2.43
		4	-1360	-1320	4.49	4	-200	0	5.38
		5	-1020	-1000	2.28				
		6	-960	0	182.83 ***				
Integration	*Autistic*								
		1	300	1000	90.68 ***	1	400	1000	-93.07 ***
	Typically developing								
		1	400	1000	102.81 ***	1	400	1000	-105.7 ***

Anticipatory fixations towards target: As is clear in Figure 3.2., preference to fixate the target object increased over the 3000ms anticipatory period, reflected in significant effects on the linear, quadratic and cubic fit curves. More importantly, Group significantly interacted with the cubic fit, revealing that while both groups clearly exhibited an increasing target preference prior to disambiguation, participants in the TD group exhibited shallower curvature- a slower rate of target bias increase- compared to the autistic group. Permutation tests confirmed that TD participants first showed a significant bias to fixate the target from 2240ms before disambiguation (*SumT* = 115.40, $p < .001$), but this subsequently plateaued between 1500ms and 1000ms, then rapidly increased from 960ms onwards (*SumT* = 182.83, $p < .001$). In contrast, autistic participants showed a sustained and increasing bias to fixate the target from 1800ms before disambiguation onwards (*SumT* = 392.02, $p = .001$).

Anticipatory fixations towards competitor: A significant effect on the linear fit curve revealed that overall preference to fixate the competitor object increased over the 3000ms anticipatory period. Importantly, this linear fit interacted significantly with Group, showing that the autistic group exhibited a steeper rise in looks to the competitor compared to the TD group. Permutation tests revealed that while TD participants never fixated the competitor above chance level during the 3000ms anticipation period (all *ps* > .05), autistic participants showed a significant bias to fixate the competitor between 1000ms and 300ms before disambiguation (*SumT* = 22.31, $p = .001$).

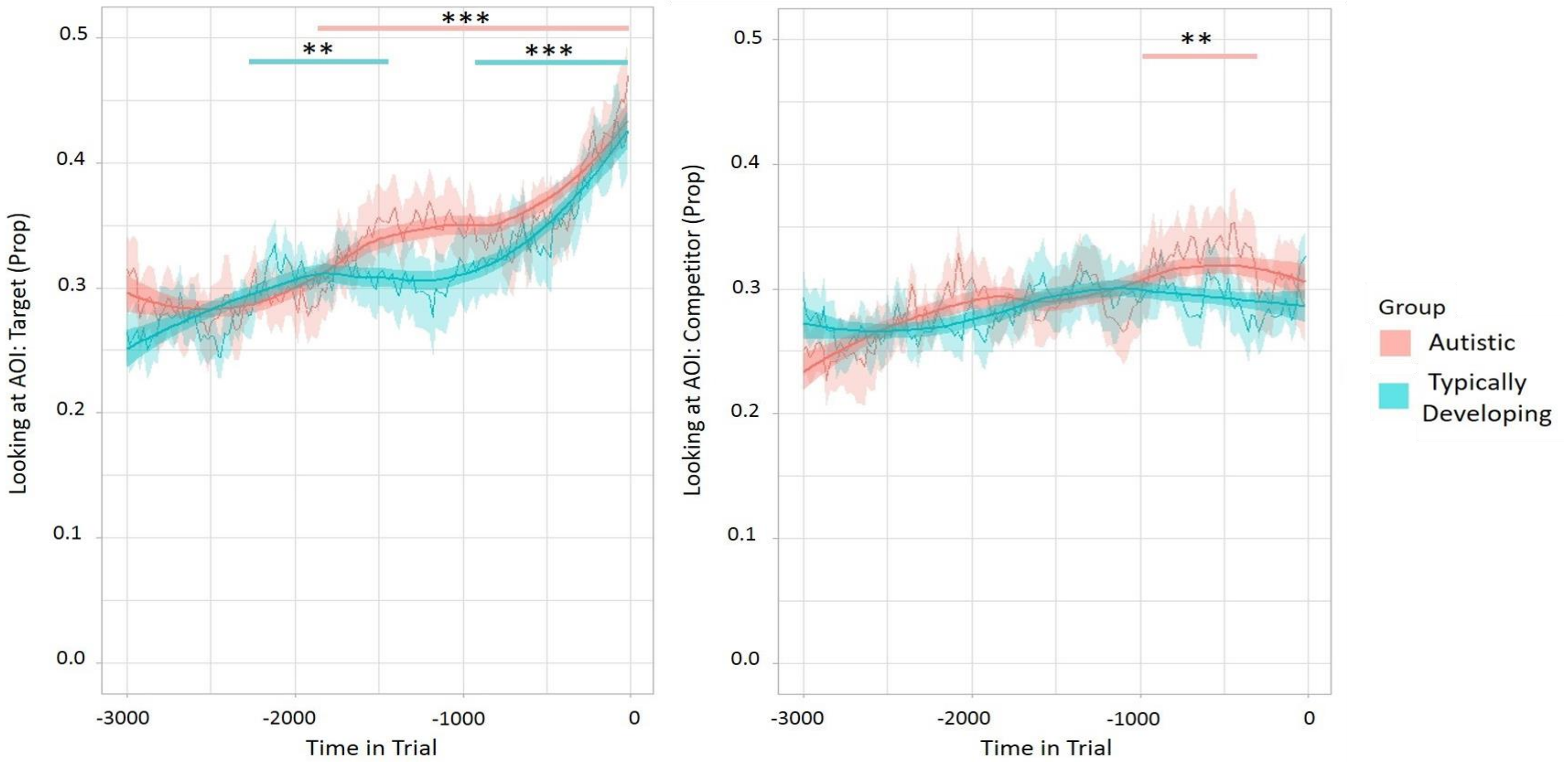


Figure 3.2. Timecourse of anticipatory fixations towards the target (left panel) and competitor (right panel) pictures for each group, in Experiment 4, showing the best fit curves for the data and 95% confidence interval shadow. Horizontal lines show clusters of time where the fixations towards the target exceeded chance (* $p < .05$, ** $p < .01$, *** $p < .001$).

Integration fixations towards target: The timecourse plots in Figure 3.3. reveals that looks to the target continued to rise when the mentioned object was consistent with the speaker characteristics, but showed a steep decrease when the mentioned object was inconsistent with the speaker characteristics. Permutation analysis showed that in the autistic group, a significant difference in fixations towards the target emerged between consistent and inconsistent conditions from 300ms after the disambiguating word ($SumT$ = 90.68, $p < .001$). In contrast, the TD group showed this same effect from 400ms after the disambiguating word ($SumT$ = 102.81, $p < .001$).

Integration fixations towards competitor: The timecourse plots in Figure 3.3. reveals that looks to the competitor rose steeply when the mentioned object was inconsistent with the speaker characteristics, but decreased when the mentioned object was consistent with the speaker characteristics. Permutation analysis revealed that a significant difference in fixations towards the competitor emerged between consistent and inconsistent conditions from 400ms after the disambiguating word in both the autistic ($SumT$ = -93.07, $p < .001$) and TD group ($SumT$ = -105.70, $p < .001$).

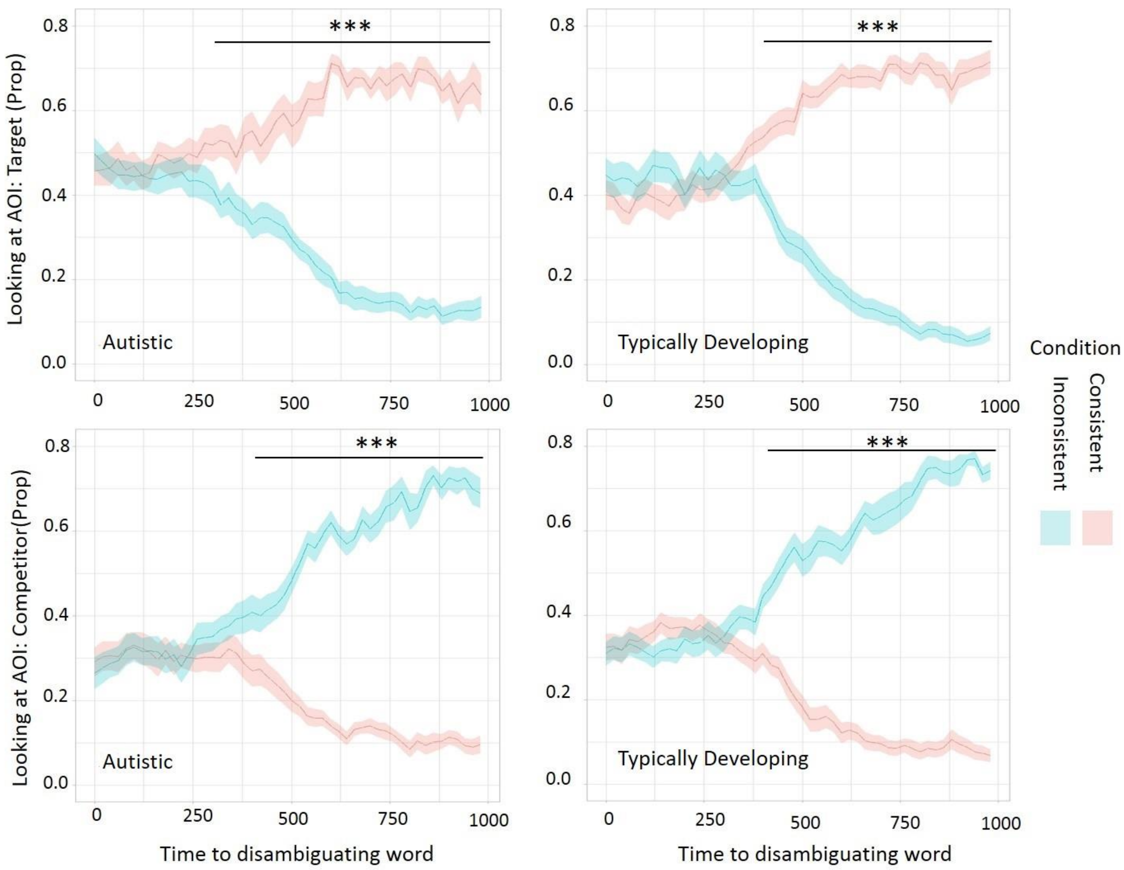


Figure 3.3. Timecourse of integration fixations towards the target (top panels) and competitor (bottom panels) for each consistency condition and group, Experiment 4. The horizontal lines above them show the points at which the fixations towards the AOI in different condition first became significant.

3.2.3. Summary

The results of Experiment 4 revealed that participants in both groups accurately used the speaker's voice to anticipate the speaker's intended message. Participants were slower to select the mentioned object when it was inconsistent with the speaker's voice than when it was consistent with the speaker's voice. The influence of speaker expectations was also evident in the eye movement data as participants in both groups showed a strong and increasing preference to fixate the object that was consistent with speaker's voice (i.e. the target) long before hearing the disambiguating word. Importantly, the nature and timing of these visual biases showed subtle differences between groups. Specifically, the target bias emerged earlier among participants in the TD group (TD: 2240ms *vs* autistic: 1800ms prior to disambiguation), but showed shallower curvature, as the bias stalled before a final rapid increase from 960ms before the disambiguation point. In contrast, participants in the autistic group showed a consistent steep increase in the visual bias towards the speaker-consistent object from 1800ms before the disambiguation point. Interestingly, only the autistic group showed an above-chance bias to fixate the competitor during this anticipatory period. As expected, following the disambiguating word, participants in both groups made increasing fixations towards the mentioned object, regardless of whether it was consistent or inconsistent with the speaker expectations. As in the anticipatory period, some subtle differences emerged between groups; the autistic group were faster to switch *away from* the target in the inconsistent condition compared to the TD group (300ms *vs* 400ms respectively). Both groups were equally fast to switch *to* the competitor in this inconsistent condition.

Taken together, these findings provide strong evidence that participants used the voice to infer characteristics of the speaker, and rapidly anticipated their intended meaning. This finding provides further evidence for the one step model of language processing by showing that the relevant knowledge and social context are processed hand-in-hand with semantics to facilitate language processing (Clark, 1996; Perry, 1997). The fact that these online voice-based inferences of meaning were generated by autistic adults is important because this is in contrast with several prominent theories of autism, including the WCC theory, suggesting that autism is associated with a tendency to process the information locally first and only later switching to global processing and using the context, including the social context (Booth, & Happé, 2010; Frith, & Happé, 1994). Nevertheless, the subtle differences in timing and strength of effects revealed by eye-tracking suggest that the autistic group had weaker speaker-meaning expectations, perhaps due to greater interference from the competitor or having weaker social stereotypes. In addition, TD participants' eye movements showed a clear cubic pattern of looks to the target over time (i.e. an increasing bias towards the target, followed by a plateau, then a final increase until disambiguation), though they never fixated the competitor object above chance. It is possible that this temporary reduction of the target bias reflects greater exploration of the visual scene and the irrelevant distractor objects among participants in the TD group compared to the autistic group (Heaton & Freeth, 2016).

In Experiment 5, we sought to further examine how people integrate these social contrasts using event-related potentials (ERPs). ERPs were recorded while participants listened to sentences that were either consistent or inconsistent with the speaker's characteristics. We predicted that there will be a larger N400 effect while participants hear the sentences in the inconsistent condition compared to the consistent one. In other words, they will show greater difficulty to integrate the sentence when there is a social contrast. We predicted that if autistic individuals have problems to integrate the information from context, then they would show less sensitivity while hearing these social contrasts (i.e. an absent or a reduced N400 effect in this group). We also included semantic anomalous sentences as a baseline measure of the anomaly detection N400 effect.

3.4. Experiment 5

3.4.1. Method

This experiment was conducted concurrently with Experiment 4, hence the participants were identical to those described in Experiment 4 (N=48). This sample size was defined a-priori to match that used (for each group) in Van Berkum et al. (2008), and it is comparable to or exceeds the sample sizes of previous studies that have used EEG to study language in autism (e.g. Coderre, Chernenok, Gordon, & Ledoux, 2017; Korpilahti et al., 2007; Pijnacker, Geurts, Van Lambalgen, Buitelaar, & Hagoort, 2010; Lartseva, Dijkstra Kan, & Buitelaar, 2014). Nevertheless, post-hoc power calculations showed an estimated power of approximately 38% to detect a significant 4-way interaction. We would have needed more than 135 participants (i.e. ~68 autistic individuals, as well as ~68 age- and IQ-matched controls) to reach 80% power, which would not be feasible using these complex methods and given the difficulties associated with recruiting and testing autistic people.

All methodological procedures were pre-registered on the Open Science Framework (OSF) web pages (see https://osf.io/7hna3/).

3.4.1. Materials

The experimental and filler sentences used in this study were based on those used in Van Berkum et al.'s study (2008). 160 speaker-consistent and speaker-inconsistent experimental sentences were translated from Dutch to English, and adapted to ensure they matched English sociocultural stereotypes, names and places. Each sentence included a single, sentence medial, critical word that was either consistent or inconsistent with the speaker (critical words are underlined in the following examples). There were 40 sentences in the age category: 20 adult vs 20 child type sentences (e.g. “I drink a glass of wine every night before I go to sleep”, “I cannot sleep without my teddy in my arms”), 40 sentences in the class category: 20 stereotypical high class vs 20 stereotypical lower class type sentences (“Every month, we go to the opera for a night out”, “I have a large tattoo on my back”) and 80 sentences in the gender category: 40 stereotypical female vs 40 stereotypical male type sentences (e.g. “I bought a very comfortable bra from an expensive shop”, “Every week I trim my beard with a small pair of scissors”). A third semantic anomaly condition was created by replacing the critical word in each sentence with a semantically anomalous word (e.g. I cannot sleep without my pizza in my arms”), matched in length and syllables to the consistent/inconsistent conditions. This condition provides a within-subjects baseline measure of the anomaly detection N400 effect (note that this differs from Van Berkum’s study that tested semantic anomaly sentences in a separate experiment). In addition, 60 filler sentences were created to balance the number of sentences presented with anomalous/inconsistent content (as in Van Berkum et al., 2008). Thus, 30 sentences described ‘true’ events (e.g. “The dog usually sleeps in his basket in the living room”) and 30 sentences described ‘semantically correct’ information (e.g. “The Sahara is a place that is very dry and hot”).

Sentences were recorded by 14 different speakers. Sentences in the age category were read by four speakers: 2 adult speakers (one female and one male) and two child speakers (one female age 6 and one male age 8). Four adult speakers, 2 females and 2 males, read the sentences in the gender category, and four professional actors (2 males and 2 females) were recruited to imitate the stereotypical higher vs lower class British accents for the sentences in the class category (one male and one female to each class category). Audios were recorded in a sound proof room using a digital voice recorder. Two further adult speakers (one female and one male) read the filler sentences. All speakers were native speakers of English.

To ensure the validity of our items and speakers, we conducted a post-test, in which 12 TD males and 12 TD females were asked to rate the plausibility of each experimental audio on a 5-point scale: “how normal or strange you think it is to have the speaker say this particular thing” (1 = completely normal, 5 = very strange). A 1-way ANOVA testing the effect of consistency (consistent *vs* inconsistent *vs* semantic anomaly) revealed a significant effect of consistency ($F(2, 142) = 340.11$, $p < .001$, $\eta 2 = .83$), with participants rating the semantic anomalous ($M = 3.80$ *vs* 1.47, $t = 22.09$, $p < .001$) and inconsistent ($M = 2.23$ *vs* 1.47, $t = 11.85$, $p < .001$) audios as less plausible, compared to the consistent ones. Semantic anomalous audios were also rated as less plausible compared to the inconsistent ones ($M = 3.80$ *vs* 2.23, $t = 15.98$, $p < .001$). To verify that this consistency effect held for all three speaker types, we conducted separate 1-way ANOVAs for each speaker type (i.e. age, gender and class). This revealed a significant effect of consistency for all three speaker types: (age: $F(2, 142) = 226.58$, $p < .001$, $\eta 2 = .76$; gender: $F(2, 142) = 338.38$, $p < .001$, $\eta 2 = .83$; class: $F (2, 142) = 278.93$, $p < .001$, $\eta 2 = .80$), reflecting the same pattern of lower plausibility ratings for semantic anomalous and inconsistent audios compared to consistent audios.

Three presentation lists were created, with each list containing one hundred and sixty experimental items, 53 or 54 in each of the three conditions. The one hundred and sixty experimental items in each list were interspersed randomly among sixty unrelated filler sentences to create a single random order and each subject only saw each target sentence once, in one of the three conditions. Participants were randomly assigned to read each list.

3.4.2. Procedure

Participants were informed about the EEG procedure and experimental task. After electrode application they were seated in a booth where they listened to the spoken sentences through speakers, while a fixation cross was presented on a computer screen (presented using E-Prime software). There were two practice trials to familiarize participants with the procedure, after which the experimenter answered any questions. Each trial began with the presentation of a single centrally-located red fixation cross for 500 ms to signal the start of a new trial. After this time, a white fixation cross appeared for 500 ms. The target sentence was then presented auditorily, with the white fixation cross remaining on-screen throughout. A 1000 ms blank-screen interval followed each item. There was no secondary task. Trials appeared in five blocks of 44 sentences, each lasting ~6 minutes. Each block was separated by a break, the duration of which was determined by the participant. The EEG task, including setup, took approximately 60 minutes to complete.

EEG recording and data analysis: A Brain Vision Quickamp amplifier system was used with an ActiCap cap for continuous recording of electroencephalographic (EEG) activity from 30 active electrodes over midline electrodes Fz, Cz, Pz, and Oz, over the left hemisphere from electrodes Fp1, F3, F7, FC1, FC5, C3, T7, CP1, CP5, TP9, P3, P7, O1, and from the homologue electrodes over the right hemisphere. EEG and EOG recordings were sampled at 500 Hz, and electrode impedance was kept below 10 kΩ. Off-line, all EEG channels were recalculated to an average mastoid reference.

Prior to segmentation, EEG and EOG activity was band-pass filtered (.05-70 Hz, 12 dB/oct), and EEG activity containing blinks was corrected using a semi-automatic ocular ICA correction approach (Brain Vision Analyzer 2). The continuous EEG record was then segmented into epochs of 2000 ms, starting 500 ms prior to the onset of the target word (e.g. 'teddy' in the sentence "I cannot sleep without my teddy in my arms"). Thus, the post-stimulus epoch lasted for a total duration of 1500 ms. Semi-automatic artifact detection software (Brain Vision Analyzer 2) was run, to identify and discard trials with non-ocular artifacts (drifts, channel blockings, EEG activity exceeding ±50 μV). This procedure resulted in an average of 43 trials retained for analysis, per condition.

Procedures for the analysis of EEG data replicated those used in Van Berkum's study. First, the signal at each electrode site was averaged separately for each experimental condition, time-locked to the onset of the target word, and aligned to a 200 ms pre-target baseline. Mean ERP amplitude was determined in five time widows, replicating those used in Van Berkum et al. (2008) and in line with our pre-registered analysis plans: 100-200ms, 200-300ms, 300-500ms, 500-700ms, and 200-700ms. ERP amplitudes over lateral electrodes sites were analysed using four regions of interest (ROIs). Lateral electrodes were divided along a left-right dimension, and an anterior-posterior dimension. The two ROIs over the left hemisphere were: left-anterior (Fp1, F7, F3, FC5, FC1), and left-posterior (CP5, CP1, P7, P3, O1); two homologue ROIs were defined for the right hemisphere. ERP amplitudes over midline electrodes (Fz, FCz, Cz, Pz, Oz) were analysed in a single AOI, calculated by averaging data over the five electrodes, and analysed separately from data recorded over lateral electrode sites. This procedure was chosen based on previous literature, which has established N400 as a linguistically relevant negative going ERP component. N400 usually peaks around 400-600 msec after hearing a semantically anomalous word within a sentence or even a coherent word that semantically does not fit with the predictions or the context of the sentence. This component sometime peaks after only having heard two or three phonemes of the target word which also encouraged us to look into the earlier time-windows. Hence, if voice inferences are processed within the same early processes that examine semantics then we would expect a similar ERP effect (i.e. N400 effect) over central or posterior electrodes (Van den Brink, Brown, & Hagoort, 2006).

3.4.2. Results

All analysis procedures were pre-registered, and the full experimental materials, datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/7hna3/).

Linear mixed models and lmer in the lme4 package in RStudio software were used to analyse the ERP data (Bates, et al., 2018; Version 1.1.453, R Core Team, 2016;). We note that our pre-registration planned to use ANOVAs to analyse the ERP data, replicating Van Bekrum et al. (2008), however in line with analyses for Experiment 4 and more recent statistical norms in the field, we adapted this plan to use linear mixed models since this allowed us to include random effects for both participants and items, and a maximal random effects structure. Thus, over lateral electrodes, each model included fixed effects of Group, AntPos, Hemisphere and Condition, and random effects for items and participants. Over the midline electrodes, each model included fixed effects of Group and Condition, and random effects for items and participants. Fixed effects with two levels (i.e. Group, Hemisphere, AntPos) were contrast coded (-.5 *vs* .5). To accommodate the three levels of Condition, we used deviation coded contrast schemes to compare each of the experimental conditions to the consistent reference level: Consistent *vs*. Inconsistent (Consistent (-.33), Inconsistent (.66), Anomalous (-.33)) and Consistent *vs*. Anomalous (Consistent (-.33), Inconsistent (-.33), Anomalous (.66)).

The maximal random effects structure over lateral electrodes included crossed random slopes for Group, AntPos, Hemisphere and Condition within items, and crossed random slopes for AntPos, Hemisphere and Condition within participants. Over midline electrodes, the maximal random effects structure included crossed random slopes for Group and Condition within items, and a random slope for Condition within participants. Some of the random slopes were removed later due to the non-convergence of the model (as suggested by Barr et al., 2013). The final models used to analyse the data across the different time windows are presented in the supplementary material. Note that due to space constraints, only significant or marginal ($p \leq .06$) effects are presented in the text. Full statistical effects for each time window are summarised in Table 3.4, and grand average waveforms for each condition/group are shown in Figure 3.4.

Table 3.4. Statistical results from the analysis of N400 effects over lateral and midline electrodes in Experiment 5, where · p<.1, * p<.05, ** p<.01, *** p<.001.

		100-200ms			200-300ms			300-500ms			500-700ms			200-700ms		
		Est.	*SE*	*t-value*	*Est.*	*SE*	*t-value*	*Est.*	*SE*	*t-value*	*Est.*	*SE*	*t-value*	*Est.*	*SE*	*t-value*
Lateral	AntPos	0.19	0.08	2.43 *	0.3	0.06	4.93***	0.11	0.07	1.56	0.24	0.08	2.91**	0.22	0.07	3.41***
	Hemisphere	-0.07	0.05	-1.24	-0.24	0.06	-0.39	0.11	0.07	0.16	-0.02	0.08	-0.3	-0.01	0.07	-0.13
	Group	-0.05	0.12	-0.38	-0.16	0.12	-1.33	-0.13	0.15	-0.87	-0.22	0.16	-1.33	-0.17	0.14	-1.26
	Consistent vs. Anomaly	-0.12	0.11	-1.13	-0.13	0.08	-1.72	-0.25	0.13	-1.95 ·	-0.44	0.1	-4.38***	-0.31	0.15	-2.02*
	Consistent vs. Inconsistent	-0.23	0.12	-1.82	-0.23	0.08	-3.02**	-0.22	0.12	-1.86 ·	-0.2	0.1	-1.96 ·	-0.22	0.14	-1.51
	Ant-Pos*Hemisphere	0.04	0.11	0.4	0.02	0.12	0.15	-0.03	0.14	-0.22	-0.11	0.16	-0.73	0.01	0.13	0.08
	Ant-Pos*Group	-0.01	0.15	-0.8	-0.34	0.12	-2.74**	-0.26	0.14	-1.91 ·	-0.35	0.16	-2.12*	-0.26	0.13	-1.97*
	Hemisphere*Group	0.12	0.11	1.09	0.03	0.12	0.21	0.07	0.14	0.54	0.15	0.16	0.9	0.1	0.13	0.73
	Ant-Pos*Consistent vs. Anomaly	-0.11	0.13	-0.81	-0.09	0.15	-0.57	0.02	0.17	0.1	-0.1	0.2	-0.5	0.04	0.16	0.26
	Ant-Pos*Consistent vs. Inconsistent	-0.01	0.13	-0.12	-0.001	0.15	-0.57	0.02	0.17	0.14	-0.18	0.2	-0.92	-0.08	0.16	-0.48
	Hemisphere*Consistent vs. Anomaly	0	0.13	0	0	0.15	-0.01	0.03	0.17	0.18	0.06	0.2	0.31	0.05	0.16	0.3
	Hemisphere*Consistent vs. Inconsistent	0.08	0.13	0.6	0.09	0.15	0.61	0.2	0.17	1.15	0.02	0.2	0.11	0.1	0.16	0.62
	Group*Consistent vs. Anomaly	0.05	0.17	0.33	-0.16	0.15	-1.05	-0.17	0.26	-0.67	-0.26	0.2	-1.27	-0.23	0.23	-0.99
	Group*Consistent vs. Inconsistent	0.19	0.21	0.88	0	0.15	-0.03	-0.26	0.23	-1.12	0.01	0.2	0.07	-0.12	0.22	-0.55
	Ant-Pos*Hemisphere*Group	0.2	0.21	0.95	0.18	0.25	0.73	0.12	0.28	0.43	0.1	0.33	0.3	-0.12	0.26	0.96
	Ant-Pos*Hemisphere*Consistent vs. Anomaly	-0.16	0.26	-0.61	-0.16	0.3	-0.53	-0.2	0.34	-0.59	-0.13	0.4	-0.32	0.2	0.33	0.19
	Ant-Pos*Hemisphere*Consistent vs. Inconsistent	-0.04	0.26	-0.16	-0.12	0.3	-0.41	-0.19	0.34	-0.57	-0.32	0.4	-0.79	0.06	0.33	-0.78
	Ant-Pos*Group*Consistent vs. Anomaly	0.06	0.26	0.23	-0.12	0.3	-0.4	-0.2	0.34	-0.58	0.12	0.4	0.29	-0.26	0.33	0.4
	Ant-Pos*Group*Consistent vs. Inconsistent	0.03	0.26	-0.13	0.05	0.3	0.17	-0.07	0.34	-0.21	0.23	0.4	0.56	0.13	0.33	0.14
	Hemisphere*Group*Consistent vs. Anomaly	0.21	0.26	0.79	0.23	0.3	0.77	0.36	0.34	1.05	0.63	0.4	1.57	0.05	0.33	1.44
	Hemisphere*Group*Consistent vs. Inconsistent	0.32	0.26	1.22	0.45	0.3	1.48	0.41	0.34	1.2	0.53	0.4	1.31	0.46	0.33	1.4
	Ant-Pos*Hemisphere*Group*Consistent vs. Anomaly	0.05	0.52	0.1	0.19	0.61	0.31	0.13	0.68	0.18	-0.05	0.81	-0.06	0.52	0.65	0.79
	Ant-Pos*Hemisphere*Group*Consistent vs. Inconsistent	0.14	0.52	0.26	0.17	0.61	0.28	-0.02	0.68	-0.03	-0.07	0.81	-0.09	-0.05	0.65	-0.08
Midline	Group	-0.19	0.12	-1.57	-0.35	0.14	-2.43*	-0.36	0.18	-1.98 ·	-0.51	0.19	-2.62*	-0.42	0.16	-2.55*
	Consistent vs. Anomaly	-0.24	0.13	-1.82 ·	-0.19	0.15	-1.25	-0.34	0.16	-2.12*	-0.57	.19	-2.91**	-0.40	0.16	-2.55*
	Consistent vs. Inconsistent	-0.37	0.15	-2.48*	-0.31	0.17	-1.82 ·	-0.16	0.16	-1.02	-0.23	0.19	-1.26	-0.22	0.16	-1.41
	Group*Consistent vs. Anomaly	0.21	0.27	0.78	-0.27	0.33	-0.83	-0.22	0.32	-0.68	-0.10	0.37	-0.26	-0.18	0.31	-0.57
	Group*Consistent vs. Inconsistent	0.41	0.30	1.34	0.08	0.36	0.22	-0.31	0.32	-0.97	0.19	0.37	0.5	-0.04	0.31	-0.12

100-200ms: Analyses revealed a significant effect of AntPos, with a more negative waveform over anterior electrode sites (*M* = -.24μV) compared to posterior electrode sites (*M*= -.05μV). More importantly, the speaker-inconsistency effect was significant over the midline electrodes, revealing a more negative wave in the inconsistent condition (*M*= -.45μV) compared to the consistent condition (*M*= -.09 μV). The semantic anomaly effect was marginally significant over the midline electrodes, showing a more negative wave in the semantic anomalous condition (*M*= -.32 μV) compared to the consistent condition (*M*= -.09μV). The effect of Group was not significant, and Group did not interact with any other variables.

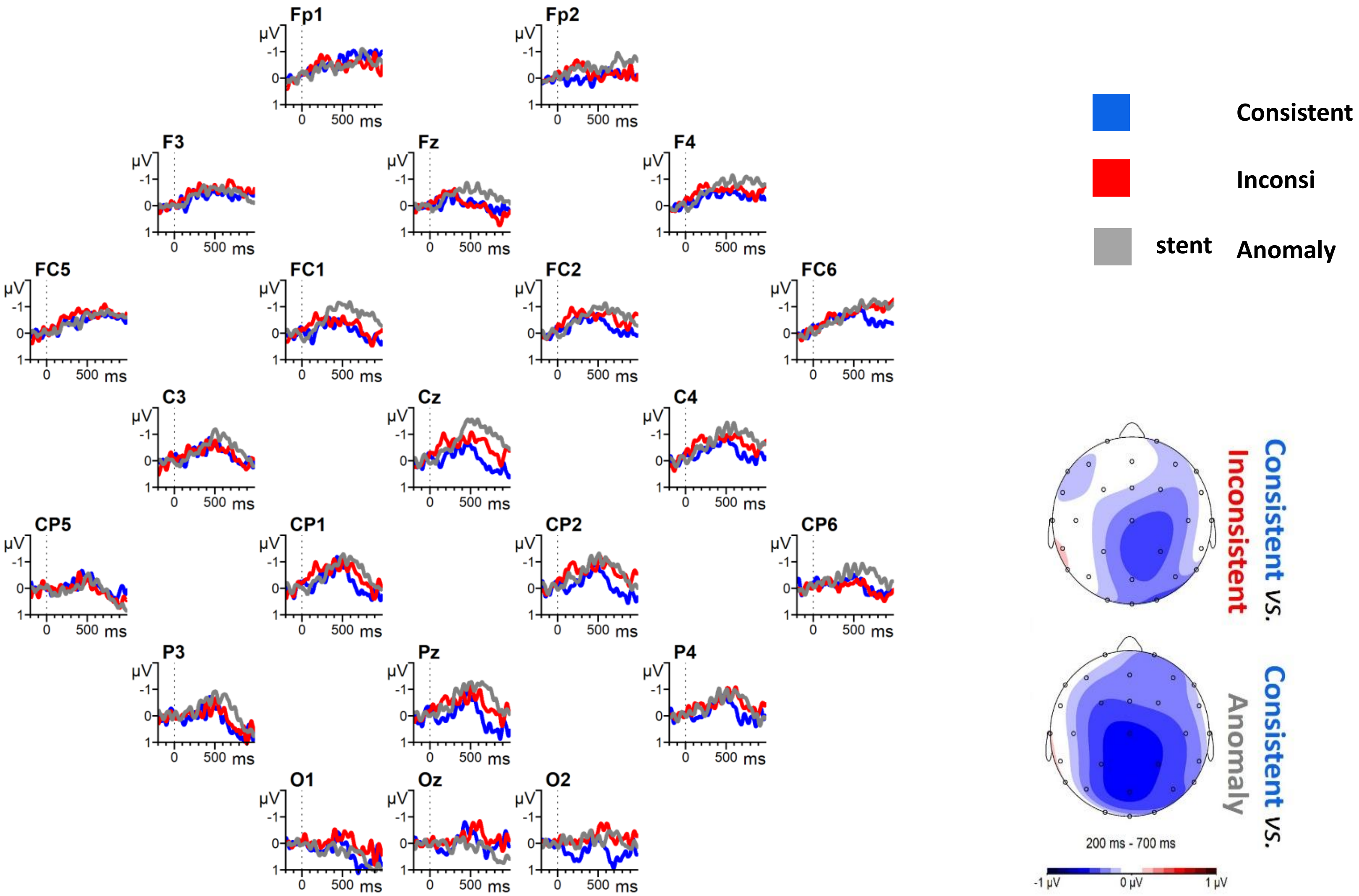
200-300ms: A significant effect of AntPos once again showed a more negative waveform over anterior electrode sites (*M*= -.43μV) than posterior electrode sites (*M*= -.13μV). The speaker-inconsistency effect was significant over lateral electrodes and marginal over the midline, revealing a more negative wave in the inconsistent condition ($M_{lateral}$= -.40μV, $M_{central}$= -.59 μV) compared to the consistent condition ($M_{lateral}$= -.16μV, $M_{central}$= -.28μV) Over the midline electrodes there was a significant effect of Group, reflecting a more negative wave in the TD group (*M*= -.62μV) compared to the autistic group (*M*= -.27μV). There was also a significant interaction between Group and AntPos. Post-hoc comparisons revealed a more negative wave over anterior (*M*= -.45μV) compared to posterior electrodes (*M*= .02μV) in the autistic group (*Est.* = 0.45, *SE* = 0.17, t = 2.60, p = 0.015), but no difference in the TD group (t = 1.16, p = 0.258). None of the remaining effects or interactions involving Group or semantic anomaly were significant.

300-500ms: The effects of speaker-inconsistency and semantic anomaly were marginally significant over the lateral electrodes, and the semantic anomaly effect was significant over midline electrodes. As expected, the N400 was more negative for the inconsistent (*M*= -.51μV) and semantic anomaly (*M*= -.52μV) conditions, compared to the consistent condition (*M*= -.29μV). The effect of Group was marginal over the midline electrodes, showing a larger overall N400 in the TD group (*M*= -.84μV) than the autistic group (*M*= -.49μV). None of the remaining effects or interactions involving Group reached significance.

500-700ms: The effect of speaker-inconsistency was significant over the lateral electrodes, with a larger N400 in the inconsistent (*M*= -.50μV) compared to consistent condition (*M* = -.30μV). The effect of semantic anomaly was significant over both lateral and midline electrodes, reflecting a larger N400 in the semantic anomaly condition ($M_{lateral}$= -.73μV, $M_{central}$= -1.00μV) compared to the consistent condition ($M_{lateral}$= -.30μV, $M_{central}$= -.44μV). Once again, the effect of Group was significant over the midline electrodes, with larger N400 effects in the TD group (*M* = -.95μV) than in the autistic group (*M* = -.45μV). Post-hoc comparisons revealed a more negative wave over anterior (*M*= -.62μV) compared to posterior electrodes (*M*= -.21μV) in the autistic group (*Est.* = 0.40, *SE* = 0.19, *t* = 2.10, *p* = 0.048), but no difference in the TD group (*t* = 0.43, *p* = 0.669). None of the remaining effects or interactions involving Group reached significance.

200-700ms: Analyses over lateral electrodes revealed a significant effect of AntPos, with a more negative N400 over anterior electrode sites (*M* = -.55μV) compared to posterior electrode sites (*M* = -.33μV). The semantic anomaly effect was significant over both lateral and midline sites, reflecting a larger N400 in the semantic anomaly condition ($M_{lateral}$= -.56μV, $M_{central}$= -.83μV) compared to the consistent condition ($M_{lateral}$= -.27μV, $M_{central}$= -.43μV). Over the midline, the N400 was significantly more negative in the TD group (*M*= -.84 μV) compared to the autistic group (*M*= -.43). There was also a significant interaction between Group and AntPos. Post-hoc comparisons revealed a more negative wave over anterior (*M*= -.54μV) compared to posterior electrodes (*M*= -.18μV) in the autistic group (*Est.* = 0.34, *SE* = 0.16, t = 2.10, p = 0.046), but no difference in the TD group (t = 0.89, p = 0.383). None of the remaining effects or interactions involving Group reached significance.

Autistic group



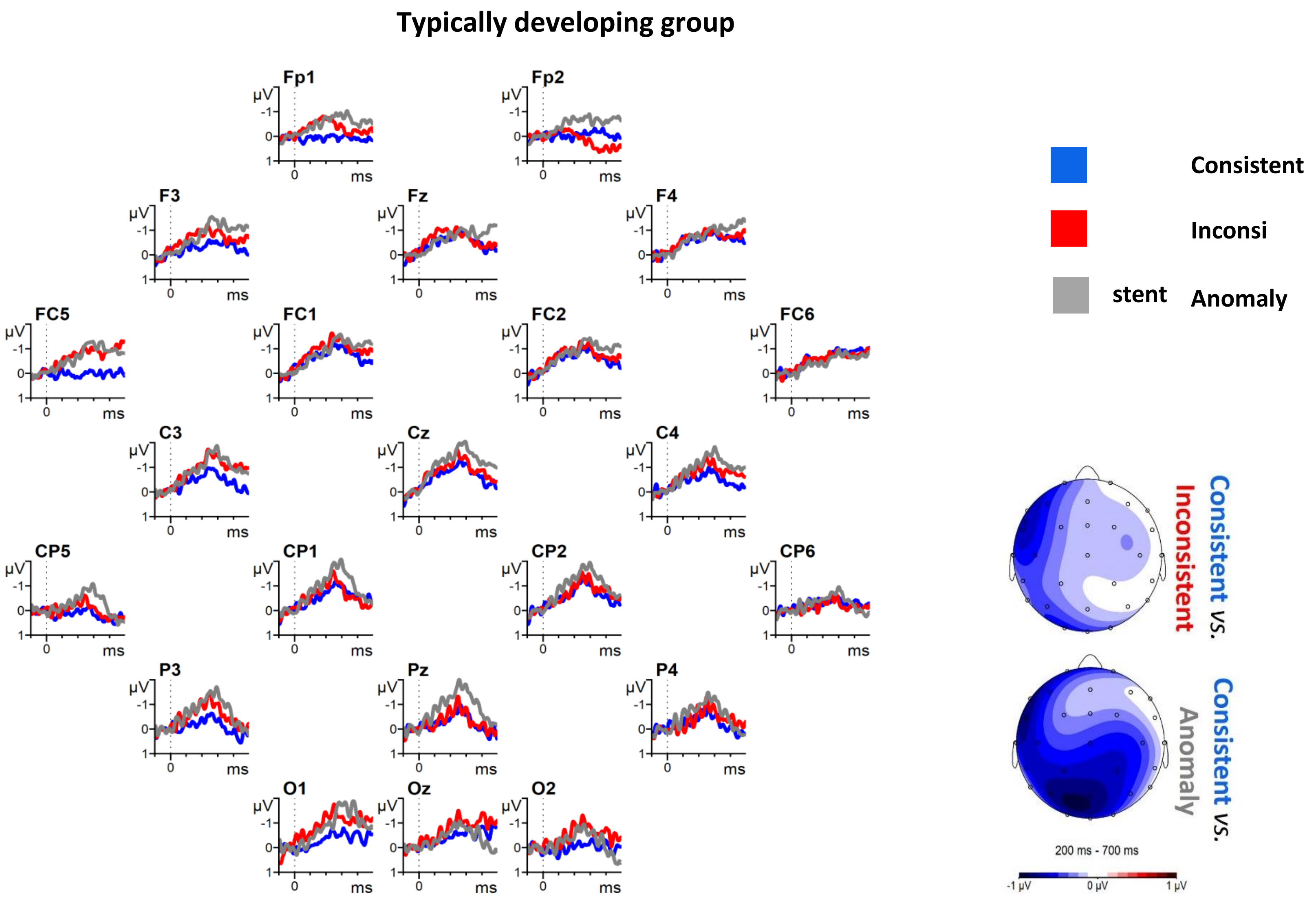


Figure 3.4. Grand-average ERPs elicited by critical words in the autistic group (top panel) and TD group (bottom panel) for Consistent, Inconsistent and Anomalous speaker conditions. Note that negativity is plotted upwards.

3.4.3. Summary

First, the results of Experiment 5 replicated van Berkum et al.'s findings (2008), showing that individuals integrated their world knowledge (voice-based inferences in our study) and the semantics of the sentence to detect an inconsistency between the speaker's voice and meaning as early as 200-300ms after hearing the critical word. Second, the speaker inconsistency effect emerged within a comparable timeframe to the semantic anomaly effect, perhaps even earlier. Thus, the results provide further evidence for the notion that language processing goes beyond processing the linguistic input, and that pragmatic processing can be activated immediately (Berkum, Hagoort, & Brown, 1999; Just, & Carpenter, 1980; Zwaan, 2004). Importantly, autistic individuals took the speaker's voice into account as quickly as TD individuals, showing that they were as fast to integrate pragmatics and semantics. This pattern contrasts with theories that suggest autistic individuals have difficulties in using context while processing language (Tager-Flusberg, Paul, & Lord, 2005).

3.4. General Discussion

In two pre-registered experiments we investigated the timecourse with which autistic and TD adults understand a speaker's meaning based on characteristics inferred from the speaker's voice. Experiment 4 used the visual world paradigm to capture the timecourse of *anticipated* meaning while participants listened to spoken sentences in which the speaker's voice and message were either consistent or inconsistent (e.g. "When we go shopping, I usually look for my favourite <u>wine</u>", spoken by an adult or a child). Experiment 5 recorded ERPs to examine *integration* of meaning while participants listened to spoken sentences that were either consistent or inconsistent in terms of voice and message, or semantically anomalous (e.g. “I cannot sleep without my pizza in my arms”). These experiments allowed us to test the general question of whether inferences about pragmatic meaning are activated online during language comprehension (i.e. linguistic input and context are processed in a single incremental step), or whether these pragmatic inferences are delayed to a second step of language processing (i.e. individuals first extract the sentence’s message using syntax and semantics, and only integrate the speaker’s identity at a later stage of processing). Moreover, by comparing real-time pragmatic processing of spoken language among autistic and TD people we investigated whether and how these processes are affected when global coherence and social abilities are compromised. Thus, we tested whether autistic adults would show disrupted use of context to infer meaning (i.e. replicating Happé, 1997; Jolliffe & Baron-Cohen, 1999), or whether aspects of contextual language comprehension and perspective-taking are intact among autistic people (as seen in Au Yeung et al., 2014, 2018; Black et al., 2018, 2019; Ferguson et al., 2019; Williams & Happé, 2010).

Results provided converging evidence that listeners rapidly and accurately anticipate a speaker’s intended meaning based on inferences from their voice. In Experiment 4, participants were faster to select the mentioned object when it was consistent with the speaker’s voice than when it was inconsistent. More importantly, eye movement data revealed a strong and increasing preference to fixate the object that was consistent with the speaker’s voice (i.e. the target) long before this object was disambiguated in the auditory input (~2000ms before). These incremental expectations were further evidenced in Experiment 5, as the N400 revealed that participants detected an inconsistency between the speaker's voice and meaning as early as 200ms after hearing the critical word. This speaker inconsistency effect emerged within a comparable timeframe to the semantic anomaly effect. This suggests that listeners used the inferred speaker context to constrain their expectations about forthcoming language, in a similar way that semantics and linguistic discourse context constrain expected meaning (see Van Berkum, 2009).

These findings therefore provide novel insights into the timecourse of social language understanding. In line with hypotheses from the one-step model of language processing, our data support the proposal that social context (voice of speaker here) and the linguistic input are taken into account concurrently when we process language (Clark, 1996; Perry, 1997). This early and incremental anticipation was particularly evident in Experiment 4, where eye movements provided a novel measure of predictive processing, and showed that voice-related processes are activated even before hearing the socially-relevant contrasts (e.g. wine/sweets). Here, participants inferred characteristics of the speaker based on their voice (i.e. their age, gender or social class), and directed their eye movements to objects in the visual scene that were consistent with this prediction, and relevant to the content of their unfolding utterance. Importantly, Experiment 4 showed that pragmatic inferences about the speaker modified constraints based on lexical-semantic input. In other words, while both the sweets and wine fit the semantic constraints of objects that one can buy at the supermarket, world knowledge provided cues for participants to distinguish the most relevant option for the particular speaker (e.g. adults are more likely to buy wine than sweets). This suggests that pragmatic inferences about a speaker (based on their voice) have a strong and early influence on predictive language processing, and that this is comparable to the effects seen when world knowledge constraints have been explicitly defined in the language input (e.g. 'The girl will ride the carousel/motorbike'; Kamide, Altmann, & Haywood, 2003). Alternatively, the results could also indicate that listeners were estimating the likelihood of the target referent being mentioned by the speaker by using associative semantic processes. We tried to minimise this effect as much as possible by including a competitor picture that matched the content of the sentence but not the voice stereotypes. Further evidence of these rapid pragmatic inferences was seen in the ERP data in Experiment 5, which replicated and extended the results from Van Berkum et al. (2008)'s study. Here, the N400 was amplified for inconsistent speaker-meaning sentences relative to consistent speaker-meaning sentences. Indeed, speaker inconsistency effects emerged as early as 200ms after critical word onset. This suggests that listeners already had strong predictions about the unfolding language, and the sorts of objects the speaker was most likely to mention, based on world knowledge constraints activated by the speaker's voice. This pattern provides further evidence that these social stereotypes can overrule lexical-semantic processing, since both critical words are semantically appropriate to the sentence context, and one only becomes incongruent when meaning is interpreted based on inferred knowledge about the specific speaker. Moreover, our design allowed direct comparison of this pragmatic N400 effect with a semantic anomaly condition, and revealed that the brain's response to pragmatically infelicitous language is indistinguishable from that elicited by semantic fit. This shows that language comprehension is a dynamic process whereby people can rapidly access and integrate information based on the explicit and inferred context (including words, sentence, discourse, and world knowledge), then flexibly shift between these different constraints as appropriate.

Importantly, similar patterns of anticipation and integration based on speaker-meaning fit were found among autistic and TD people, despite the autistic group showing a significant impairment in explicitly recognizing the emotions of speakers from their voice (in the RMIV task). This finding provides evidence that autistic adults do not experience a general deficit in inferring social characteristics of speakers, or integrating information in context (as seen in Black et al., 2018, 2019; Ferguson et al., 2019; Koldewyn, et al., 2013; Mottron, et al., 2003; Plaisted et al., 2006; Van der Hallen et al., 2015). In Experiment 4, autistic participants successfully inferred the pragmatic context from the speaker's voice, and directed their visual attention to anticipate mention of the speaker-relevant target object nearly 2000ms before disambiguation. In Experiment 5, autistic individuals inferred the spoken utterance's pragmatic meaning as quickly as TD individuals, evidenced by deflections on the N400 to inconsistent speaker-meaning sentences within 200ms of hearing the critical word. These patterns provide a clear indication that autistic people are aware of social stereotypes, and can infer and apply these in real-time to constrain language comprehension. This is in line with previous research showing intact social knowledge in autism when judging attributions, such as race, age, social status etc from faces or bodies (White, Hill, Winston, & Frith, 2006; Frith, 2007; Saldaña & Frith, 2007).

This unimpaired anticipation of speaker meaning is unexpected based on accounts that characterise autism in terms of a reduced drive for global coherence (WCC account; Frith, 1989; Frith & Happé, 1994; Happé & Frith, 2006), disordered processing of complex information (Minshew & Goldstein, 1998; Minshew, Goldstein, & Siegel, 1997; Minshew, Williams, & McFadden, 2008), or atypical pragmatic integration (Happé, 1997; Jolliffe & Baron-Cohen, 1999; Nuske & Bavin, 2011). These accounts predict that autistic people would show impairments in using the context (the speaker's voice here) to predict language. For example, the complex information processing theory suggests that autistic individuals struggle with integrating the information from multiple sources or components, so these individuals would struggle completing complex tasks that involve combining information from different components (Minshew, Goldstein, & Siegel, 1997). Yet data from both experiments here showed clear effects of speaker inferences among both groups of participants. Thus, the current results are consistent with recent research that has used implicit methods to show that autistic adults have an intact ability to integrate information online during language comprehension (Au-Yeung et al., 2018; Black et al., 2018, 2019; Ferguson et al., 2019; Howard et al., 2017b), and extend this by showing that global coherence of information in autism can go beyond 'what is said' to assess 'who is saying what'. The intact contextual integration seen in Experiments 1 and 2 is also consistent with the results of the linguistic central coherence task, which did not find any evidence of a local processing bias among our autistic participants (c.f. Booth & Happé, 2010). Importantly, the fact that autistic individuals were impaired at explicitly inferring emotions from a speaker's voice in the explicit RMIV task, suggests that although autistic individuals are unimpaired at integrating social stereotypes online, they struggle with extracting more complex information offline, such as emotions, supporting the previous literature (Philip, et al., 2010; Jones et al., 2011). Hence, future studies, should examine how these individuals process complex information, including emotions or mental states online, while extracting the meaning from language.

Nevertheless, Experiment 4 revealed some subtle differences in the timecourse and strength of voice-based pragmatic inferences among TD and autistic participants, which might suggest that autistic people activated weaker speaker-meaning expectations or were less bound to these social stereotypes. First, the eye-tracking data showed that participants in the TD group biased their visual attention to the target object earlier than the autistic group (2240ms *vs* 1800ms before disambiguation), though this anticipatory bias in the TD group subsequently declined prior to a rapid increase (960ms before disambiguation), whereas the autistic group showed a consistent increase in target bias from 1800ms before the disambiguation point. Second, only the autistic group in Experiment 4 showed significant interference from the competitor object (i.e. the object that was semantically, but not pragmatically relevant to the context) during the anticipation period. Finally, analysis of the period after disambiguation (i.e. integration) showed faster switches *away from* the target in the inconsistent condition among the autistic group compared to the TD group (300ms *vs* 400ms respectively).

Taken together, these findings could suggest that autistic individuals are more likely to adopt a bottom-up (i.e. semantics first) approach to pragmatic language processing (Van den Brink et al., 2010), which means that they are less able to ignore pragmatically irrelevant information. This explanation is in line with the predictive coding theory of autism (Van Boxtel & Lu, 2013), which suggests that autistic people attribute greater weight to bottom-up errors due to meta-learning impairments, and consequently contextualise sensory signals in a less automatic way, especially when facing complicated unexpected input. Support for this predictive coding theory of autism is particularly evident in the anticipatory data from Experiment 4, where autistic adults were successfully able to predict the speaker's meaning based on their voice but were slower to do so, and exhibited weaker biases to the speaker-relevant target. In an experimental setting, these subtle differences in timing and strength of predictions are not sufficient to disrupt comprehension, however it is likely that in real-world settings, where conversation is more fast-paced and involves greater distracting sensory input, these weaker top-down predictions can have a cumulative impact on social communication. Alternatively, the different patterns might reflect a more flexible use of social stereotypes among autistic individuals compared to their TD peers. Previous research has established that autistic individuals are able to recognise and use social stereotypes (including age and social status) despite profound difficulties in mental state reasoning (Hirschfield, Bartness, White, & Frith, 2007; White, Hill, Winston, & Frith, 2006). Our data might then demonstrate that autistic people are less constrained in automatically assigning meaning according to these usual/prototypical contexts (see Zalla, Amsellem, Chaste, Ervas, Leboyer, & Champagne-Lavau, 2014). These subtle differences between groups, despite intact overt understanding of social stereotypes in autistic individuals, are analogous to recent neuroimaging research that has shown distinct patterns of brain activation during speaker-meaning integration, among autistic people and their TD peers (Groen, Tesink, Petersson, Van Berkum, Van der Gaag, Hagoort, 2009; Tesink, Buitelaar, Petersson, Van Der Gaag, Kan, Tendolkar, 2009). Based on these findings, researchers have proposed that autistic people recruit atypical brain areas to integrate social information, and may rely on compensatory mechanisms to integrate social contrasts. Hence, these subtle differences between the groups could either indicate that the autistic group were using different strategies or using the same strategies but to a different extent. Perhaps using neuroimaging techniques in future would be informative to establish the source of these subtle differences.   Finally, we note some limitations with the current experiments. First, it is possible that we simply did not have sufficient power to detect the 3- and 4-way interactions that were tested in Experiment 5. Our sample size was chosen a-priori to achieve comparable participant numbers in each group to the total sample size used in Van Berkum et al. (2008; N = 24), and to match or exceed the sample sizes used in previous studies in these areas, however post-hoc power analyses suggested that at least 68 participants would be needed in each group to reach the desired 80% power. Nevertheless, concerns about power are alleviated somewhat by our use state-of-the-art statistical methods which meant that analyses were run on individual data points rather than data aggregated across participants (thus improving power; Baayen, Davidson, & Bates, 2008), which also allowed us to control for by-participant and by-item variation in a single analysis. Moreover, given that results from Experiment 5 replicated the patterns seen in Van Berkum et al. (2008), and that group did not modulate speaker consistency effects in *any* of the five pre-registered analysis time windows (in either the midline or lateral analyses), we can feel relatively confident that the reported findings are reliable. Nevertheless, as a field, research on autism should continue to aim for larger sample sizes, ideally recruiting participants with a diverse representation on the autism spectrum to ensure generalizability of results. Another point to consider is that this study did not test whether there were any differences between groups in terms of attitudes towards social stereotypes. For example, previous studies have shown that gender dysphoria is more prevalent among autistic than TD individuals, which could influence their attitudes towards gender stereotypes (Van Der Miesen, Hurley, & De Vries, 2016). Thus, future research should consider whether norms and expectations differ between autistic and TD individuals. Furthermore, since our autistic participants were impaired at explicitly recognising others' emotions from their voices, future research should investigate whether subclinical emotional conditions, such as Alexithymia (prevalent among autistic people), correlates with the ability to understand external emotions in autism.

In conclusion, the two experiments reported here employed complementary measures to assess online processing of spoken language among autistic and TD adults. Together they provide strong evidence that language is processed in a single step, by showing that speaker-related information (i.e. social context) is processed in parallel with the linguistic input, and can over-ride salient lexical-semantic input to influence listeners' expectations of an unfolding utterance in real-time. Moreover, this ability to anticipate and integrate language meaning based on social inferences about the speaker was unimpaired among autistic people. This shows that autistic people are aware of social stereotypes, and can infer and apply these automatically to constrain language comprehension. Nevertheless, we observed subtle differences in the timecourse with which these processes are activated among autistic individuals, which might indicate a preference for bottom-up (i.e. language first) processing, or more flexible use of social stereotypes in this group. Further research is needed to determine how these social contrasts are applied in real life, where language is less structured and social cues may be less salient.

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Chapter 4: Emotional processing of ironic *vs.* literal criticism in autistic and non-autistic adults: Evidence from eye-tracking

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Emotional processing of ironic *vs.* literal criticism in autistic and non-autistic adults: Evidence from eye-tracking

RUNNING TITLE: Emotional processing of irony in autism

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Author note: All analysis procedures were pre-registered, and the full experimental materials, datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/wrk2v/)

Lay Summary: In line with research showing that autistic people have difficulties considering others' mental states, we found autistic adults were impaired at distinguishing the emotions and intentions experienced by story characters who received sarcastic comments (e.g. "That was fantastic parking" in a context where someone's parking was particularly bad). These findings highlight the difficulties that autistic people experience taking into account other peoples' intentions during communication to appropriately anticipate their emotional responses.

4.1. Abstract

Typically developing (TD) adults are able to keep track of story characters' emotional states online while reading. Filik et al. (2017) showed that initially, participants expected the victim to be more hurt by ironic comments than literal, but later considered them less hurtful; ironic comments were regarded as more amusing. We examined these processes in autistic adults, since previous research has demonstrated socio-emotional difficulties among autistic people, which may lead to problems processing irony and its related emotional processes despite an intact ability to integrate language in context. We recorded eye movements from autistic and non-autistic adults while they read narratives in which a character (the victim) was either criticised in an ironic or a literal manner by another character (the protagonist). A target sentence then either described the victim as feeling hurt/amused by the comment, or the protagonist as having intended to hurt/amuse the victim by making the comment. Results from the non-autistic adults were similar to the key findings from Filik et al. (2017), supporting the two-stage account. Importantly, the autistic adults did not show comparable two-stage processing of ironic language; they did not differentiate between the emotional responses for victims or protagonists following ironic *vs.* literal criticism. These findings suggest that autistic people experience a specific difficulty taking into account other peoples' communicative intentions (i.e. infer their mental state) to appropriately anticipate emotional responses to an ironic comment. We discuss how these difficulties might link to atypical socio-emotional processing in autism, and the ability to maintain successful real-life social interactions.

Keywords: Language comprehension, irony, sarcasm, perspective, emotion, eye-tracking, autism

Figurative language is widely used in social situations to describe different emotions (Fussell & Moss, 1998). Irony is a form of figurative language that incorporates cues from context (e.g. facial expressions, body language, nature of the situation etc.) to convey a meaning that is opposite to the literal meaning of what is being said (Grice, Cole, & Morgan, 1975). One of the most common social functions of using irony is delivering a criticism using positive words, known as *ironic criticism* or *sarcasm*, a type of irony that is targeted towards an individual and is tightly bound to emotions (Boylan, & Katz, 2013; Shamay-Tsoory, Tomer, & Aharon-Peretz, 2005). For example, a superficially positive comment such as, "You are such a punctual person", uttered in a situation in which you are late to meet a friend actually criticises your undesirable behaviour of being late in an indirect manner. In this paper, we report a pre-registered experiment that explores the real-time processing of socio-emotional responses to verbal irony in autistic and non-autistic individuals[4] - a developmental disorder that is characterised by deficits in social functioning and emotional processing.

Ironic criticism seems to serve a set of complex and mixed social and emotional functions that go beyond simple criticism. For example, it has been suggested that through ironic criticism the speaker may also intend to evoke other emotions in the audience, such as amusement (see e.g., Filik, Brightman, Gathercole, & Leuthold, 2017, for a recent overview). The existing literature offers mixed results about the communicative functions of ironic criticism, and about the kinds of emotional response to ironic criticism expressed by both the protagonist and the victim. For example, the *tinge hypothesis* suggests that ironic criticism decreases the negative aspect of condemnation compared to literal criticism (Dews, & Winner, 1995; Dews, Winner, & Kaplan, 1995). According to this hypothesis, irony not only moderates the level of criticism expressed, but it also lessens the level of praise when giving compliments. This hypothesis has been supported in two studies by Dews and Winner (1995), who found that individuals perceived ironic compliments as less positive and ironic criticism as less negative, compared to literal compliments and literal criticism. Other researchers, however, have proposed that the level of condemnation can actually be *increased* in a more socially acceptable manner through ironic criticism (Brownell, Jacobs, Gardner, & Gianoulis, 1990; Colston, 1997). For example, Bowes and Katz (2011) demonstrated that sarcastic arguments were rated as more relationally aggressive and the recipients of these arguments were perceived as being more victimised. Interestingly, they found that

[4] We acknowledge recent debates about the terminology used to describe autism, and in this paper adopt the identity-first language recommended by autistic adults and parents in Kenny, Hattersley, Molins, Buckley, Povey, and Pellicano (2016).

the perspective that individuals adopted modulated these ratings. For example, participants rated the ironic comments as more entertaining or humorous when they were adopting the perspective of the protagonist rather than the victim.

The majority of previous research has applied ‘offline’ measures, such as questionnaires, to study the emotional aspects of processing irony in a victim *vs.* protagonist (e.g. Akimoto, & Miyazawa, 2017; Dews, et al., 1995; Leggitt, & Gibbs, 2000; Milanowicz, 2013). While these explicit measures have provided a useful means of assessing the broad emotional consequences of verbal irony, they can be limited by response biases and errors, necessarily involve disruption to processing, and do not assess processing in real-time. In contrast, recording eye-movements provides moment-to-moment reading time measures, which can be used to understand what influence the manipulated variable has on individuals’ reading behaviours, for example whether any anticipatory processes are involved or whether readers struggle with comprehending certain words/sentences by making regressions or having longer reading times (Rayner, Chace, Slattery, & Ashby, 2006). More recently, a few studies have applied online measures, such as eye-tracking and event -related brain potentials (ERPs), to investigate how readers keep track of temporal and emotional shifts in stories, and have demonstrated that readers are sensitive to mismatches between a character’s expected and described emotional states (Carminati, & Knoeferle, 2013; Carminati, & Knoeferle, 2016; Komeda, & Kusumi, 2006; Leuthold, Filik, Murphy, & Mackenzie, 2012; Munster, Carminati, & Knoeferle, 2014; Ralph-Nearman & Filik, 2018; Rinck, & Bower, 2000; Vega, 1996; Zwaan, 1996). Moreover, some researchers have examined the online processes underlying sarcasm comprehension using eye-tracking (e.g. Au-

Yeung, Kaakinen, Liversedge, & Benson, 2018; Deliens, Antoniou, Clin, Ostashchenko, & Kissine, 2018; Filik, Howman, Ralph-Nearman, & Giora, 2018; Filik, Leuthold, Wallington, & Page, 2014; Filik, & Moxey, 2010; Kaakinen, Olkoniemi, Kinnari, & Hyönä, 2014; Olkoniemi, Ranta, & Kaakinen, 2016; Olkoniemi, Johander, & Kaakinen, 2019; Olkoniemi, Strömberg, & Kaakinen, 2019; Țurcan & Filik, 2016; 2017). These studies generally find that comprehending irony incurs higher processing costs than comprehending literal language, suggesting that the salient meaning (i.e. the most familiar, frequent and conventional meaning) is activated by default and must be overridden to interpret ironic statements, irrespective of how biasing the context is (Giora, 1997; Giora, 2003).

Only one study to date has used eye-tracking methods to examine how emotional responses to verbal irony unfold online, and how perspective modulates these emotional responses (protagonist *vs.* victim). Filik et al. (2017) conducted two experiments: In the first experiment, participants were presented with short narratives (as in (1) below), in which a character (the victim) was either criticised in a sarcastic or a literal manner by another character (the protagonist). This was followed by a target sentence, in which either the victim was hurt by the comment (as in 2a) or in which the protagonist intended to hurt the victim by making the comment (as in 2b, i.e., encouraging participants to switch between perspectives).

(1) Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was fantastic/horrendous parking”.

(2a) Sandra was really hurt/amused by what she said.

(2b) Harriet had intended this to be a very hurtful/amusing thing to say.

Participants' eye movements were recorded while reading the narratives. Filik et al.'s (2017) second experiment was almost identical to the first, but here the target sentence described the victim finding the comments amusing/entertaining or the protagonist intending for the comments to be amusing/entertaining. The aim was to investigate how individuals integrate the emotional responses of hurtful *vs.* amusing, when processing ironic *vs.* literal criticism. Results from Experiment 1 showed that participants initially expected the characters to be more hurt by ironic *vs.* literal comments (i.e. they experienced greater processing difficulties, as evidenced through longer reading times, when reading about a 'hurt' response following literal than ironic criticism), but eventually integrated the hurt response more easily in the literal *vs.* ironic context (i.e. had shorter reading times on reaching the end of the sentence that described the emotional response). In addition, when the character was described as having an amused response to the comment (Experiment 2), on reaching the end of the sentence which described the emotional response, participants made fewer regressions and had shorter reading times following the ironic comments compared to the literal ones, meaning that ironic comments were later perceived as more amusing compared to literal comments. Based on these results, Filik et al. proposed a two-stage account where comprehending emotional responses to ironic criticism includes 1) an initial stage in which ironic criticism (sarcasm) increases the anticipated 'sting' of a critical comment, and 2) a later stage in which readers ultimately rationalize criticism that is delivered ironically as being less hurtful and more amusing. These findings demonstrate that readers keep track of the story characters' emotions in real-time; ironic comments were deemed harsh at first, but were later integrated with the protagonist's true intentions (i.e., to be amusing). Importantly, readers were also sensitive to perspective; they found it easier to integrate an amused response following a critical comment when adopting the perspective of the protagonist *vs.* victim.

The present study aimed to use eye-tracking for the first time to investigate the processing of emotional responses for ironic *vs.* literal criticism in autistic adults. Autism spectrum disorder (ASD) is a neurodevelopmental disorder diagnosed on the basis of social-communication difficulties, and restricted and repetitive behaviors and interests (American Psychiatric Association, 2013). These social-communication difficulties have been associated with impairments in pragmatic abilities or processing language in context (i.e. global coherence), as well as difficulties considering the intentions/mental states of others [Theory of mind (ToM); Booth, & Happé, 2010; Happé, 1997; Happé, 1993; Jolliffe, & Baron-Cohen 1999; Larkin, Hobson, Hobson, & Tolmie, 2017; Pearson, Ropar, & Hamilton, 2013]. Autistic individuals have also been shown to experience broad difficulties identifying and interpreting emotions in the self and others (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Uljarevic & Hamilton, 2013). Some researchers have shown specific impairments in figurative language understanding among autistic individuals. For example, Jolliffe and Baron-Cohen (1999) found that high functioning autistic adults were impaired at using context to interpret non-literal statements.

Taken together, these socio-emotional difficulties suggest that the autistic group would have problems processing irony and its related emotional processes. This prediction is partially borne out in early studies with children and adolescents, which have largely shown that comprehension of irony is impaired and delayed among autistic participants, compared to their typically developing peers (TD; e.g. de Villiers, 2011; Gyori, 2006; Wang, Lee, Sigman, & Dapretto, 2006). However, only a handful of studies have experimentally tested online emotional processing in narratives, or irony comprehension directly, among autistic adults. In contrast to the broader social-communication impairments described above, these studies have largely demonstrated an undiminished ability to comprehend irony and track emotional states online, thus adding to a growing literature showing that autistic adults can integrate linguistic input with context in real-time (e.g. Au-Yeung et al., 2018; Barzy, Williams, Black, & Ferguson, submitted; Black, Williams, & Ferguson, 2018; Ferguson, Black, & Williams, 2019; Howard, Liversedge, & Benson, 2017a, b, c). Specifically, Au-Yeung, Kaakinen, Liversedge, and Benson (2015) recorded eye movements while autistic and non-autistic participants read stories that could be interpreted as ironic or not, depending on the context. Results revealed an intact ability to comprehend irony in autistic participants, who used context to infer a non-literal meaning for ironic passages, albeit at a slower rate than the TD controls. Similarly, Black, Barzy, Williams, and Ferguson (2019) found that autistic adults were unimpaired, or even enhanced, in tracking a story character's emotions based on that character's goals and actions (i.e. counterfactual emotions, regret and relief) compared to TD participants. Thus, these online studies suggest that autistic adults can understand basic irony, and are able to infer complex emotions for characters in a story.

The current study makes an important contribution to this literature as it tests how autistic adults process the emotional responses to irony in real-time, thus combining the questions addressed independently in Au-Yeung et al. (2015) and Black et al. (2019). Moreover, our study is the first to examine whether/how autistic adults will track multiple story characters' perspectives in a story to distinguish the emotional intentions and responses experienced by a protagonist or victim, respectively. To this end, we conducted a pre-registered experiment that adapted the design from Filik et al. (2017), by combining the two experiments into a single experiment (i.e. we included both negative and positive emotions, and compared effects directly). Participants' eye movements were recorded while they read narratives as in (1) and (2ab), in which we manipulated the type of criticism (ironic *vs.* literal), character perspective (victim *vs.* protagonist), and emotional valence of the response (hurt *vs.* amusing), and compared these effects for autistic adults with age and IQ-matched TD adults. The degree of difficulty readers experienced integrating the text was indicated from measures of reading times and regressive eye movements (Rayner, 1998). This experiment therefore tests the speed with which readers can infer emotions and intentions for other people, and keep track of the narrative context during language processing, and therefore addresses a gap in the literature on online irony comprehension in autistic adults.

First of all, we expected to replicate the key findings from Filik et al. (2017), supporting the two-stage processing account for emotional responses to irony. Thus, we predicted that TD readers would initially find it easier to integrate a hurt response following an ironic *vs.* literal comment (i.e. on the critical emotion word itself), then later find it easier to integrate a hurt response following a literal *vs.* ironic comment, and an amused response following an ironic *vs.* literal comment. As in Filik et al., we also predicted that perspective would influence later processing (i.e. on the words following the emotion word), as it would be easier to integrate an amused response following criticism from the protagonist's perspective than the victim's perspective. Regarding how these effects might be modulated by autism, we contrasted two predictions based on previous research in this area. On one hand, if autistic adults experience impairments in processing emotions, inferring the mental states of others, and integrating information in context (as reported in Deliens, Papastamou, Ruytenbeek, Geelhand, & Kissine, 2018; Happé, 1993; Martin & McDonald, 2004), then we would expect delayed or absent integration of characters' emotional states following verbal irony, compared to TD adults. In contrast, if online irony and emotional processing are intact in autistic adults, then we would expect this group to experience the same patterns of integrating emotional states following ironic *vs.* literal criticism as TD adults, and thus Group would not interact with any other variables.

4.2. Method

All methodological procedures were pre-registered on the Open Science Framework (OSF) website (see https://osf.io/wrk2v/).

4.2.1. Participants

All the autistic and TD participants were recruited using the Autism Research at Kent (ARK) database. A total of 53 participants were initially recruited to take part in the study, but four were excluded prior to analysis due to technical problems with the eye-tracker or excessive data loss during the eye-tracking task. Hence, the final sample included 49 participants, specifically, 25 autistic adults and 24 TD adults, which is consistent with our pre-registered target sample size. This sample size was chosen *a priori* based on the sample size used in each experiment in Filik et al. (2017; N = 28), and to be comparable or even exceed the sample sizes used in previous research that has examined eye movements in reading in autistic and TD adults (e.g. Au-Yeung et al., 2015, 2018; Black et al., 2018; 2019; Ferguson et al., 2019; Howard et al., 2017abc).

Participants in each group were matched on gender, age and IQ (measured by the Wechsler Abbreviated Scale of Intelligence; WASI; Wechsler, 1999; see Table 4.1. for demographic information). All were native English speakers, and none had a diagnosis of dyslexia or reading comprehension impairment. None of the TD participants reported any current psychiatric diagnoses. All participants had normal or corrected-to-normal vision, which allowed the experimenter to conduct successful 9-point based calibration, and validation, procedures for all participants. Autistic participants had a formal diagnosis of Autism Spectrum Disorder (DSM 5, American Psychiatric Association, 2013), or Autistic Disorder, Asperger's Syndrome or Pervasive Developmental Disorder Not-Otherwise Specified (DSM-IV, American Psychiatric Association, 1994). Participants were asked to bring their diagnosis documents with them so the experimenter could confirm and make a copy for records. Current autistic traits were assessed in the autistic group by a trained, research-reliable researcher, using module 4 of the Autism Diagnostic Observation Schedule (ADOS-2 Module 4; Lord et al., 2000), and videos were double-coded to ensure reliability of scoring (see Table 4.1. for the average overall total score and standard deviation). Ten individuals in the autistic group scored lower than 7 on the ADOS-2 Module 4 (i.e. the cut off score, scores ranged between 1 to 21). All participants completed the Autism-spectrum Quotient (AQ;

Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) as a measure of self-reported autistic traits. Details of individuals' scores on each demographic criterion are available on OSF (see https://osf.io/vdqkn/).

Table 4.1. Demographic information for the autistic and TD groups, M (SD), with comparison statistics.

	ASD (n=25)	TD (n=24)	*t*-value	*p*-value	*η2*
Sex (m:f)	17:8	17:7	-	-	-
Age (years)	34.4 (10.78)	33.04 (16.88)	0.34	0.738	0.096
Verbal IQ	103.88 (11.95)	99.71 (9.62)	1.34	0.186	0.384
Procedural IQ	109.24 (19.41)	103.04 (11.94)	134	0.187	0.384
Overall IQ	106.88 (15.14)	101.79 (10.91)	1.35	0.185	0.385
Total AQ	31.52 (9.00)	20.04 (8.19)	4.66	<0.001 ***	1.334
ADOS2 Module4	8.04 (5.32)	-	-	-	-

4.2.2. Materials and design

Experimental items were based on those used in Filik et al. (2017). Each scenario consisted of three sentences. The first sentence provided the context for the protagonist to criticize the victim (e.g. "John had been scared by a huge spider in the bathroom sink and immediately ran out shouting."). The second sentence was the protagonist's critical comment, which was delivered either ironically or literally (e.g. "Anna said to him, "That was brave/cowardly."). The final target sentence indicated an emotional response either from the victim's perspective or as intended by the protagonist. This emotional response was either negative or positive (e.g. "John thought that this was a very mean/witty remark." OR "Anna had meant for this to be a very mean/witty remark."), and was expressed using a variety of words for each emotion (e.g. Hurt: insensitive, hurtful, upset, offended, mean, insulted, unkind, cruel; Amused: comical, humorous, witty, tickled, funny, amused, entertained, hilarious). An example item is shown in Table 4.2., and the full stimulus list can be found in the Appendix.

Table 4.2. Example item showing literal and ironic scenarios from the victim's or the protagonist's perspective, with negative and positive emotional critical words underlined

Literal	
Victim	John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, "That was cowardly". John thought that this was a very witty/mean remark.
Protagonist	John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, "That was cowardly". Anna had meant for this to be a very witty/mean remark.
Ironic	
Victim	John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, "That was brave". John thought that this was a very witty/mean remark.
Protagonist	John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, "That was brave". Anna had meant for this to be a very witty/mean remark.

Thus, the experiment employed a 2 x 2 x 2 x 2 mixed design, crossing three within-subjects variables, Type of criticism (ironic *vs.* literal), Perspective (victim *vs.* protagonist), and Emotional valence (hurt *vs.* amused), with a between-subjects variable, Group (autistic *vs.* TD). Eight presentation lists were created, with each list containing 56 experimental scenarios, seven in each of the eight within-subjects conditions. Participants were randomly assigned to read one list, meaning that each participant only saw each experimental sentence once, in one of the eight conditions (i.e. seven scenarios for each condition). These experimental items were presented in a random order, alongside an additional 30 filler items. None of the filler scenarios included any emotional responses, and most described interactions between two characters. Five of the fillers included direct speech, five included indirect speech, and the other 20 described mental states. Comprehension questions were included after 25% of the trials to ensure that participants maintained attention throughout the task (e.g. *Where did John see a huge spider?*). Participants used the mouse to select the correct answer from two choices (e.g. in the bathroom sink < > in the bedroom).

In addition, to obtain a comparative measure of Theory of Mind ability across groups, participants completed the Animations Task, based on Abell, Happé, and Frith (2000), in which they watched a series of silent video clips and had to describe interactions between a large red triangle and a small blue triangle. Four clips were designed to prompt an explanation of the triangles' behaviour in terms of epistemic mental states, such as beliefs, intentions, and deception. Each clip was presented to participants on a computer screen. After the clip was finished, participants described what had happened in the clip. An audio recording of participants' responses was made for later transcription.

4.2.3. Procedure

The study was approved by the School of Psychology Research Ethics Committee, at the University of Kent. Participants' eye movements were monitored using an EyeLink 1000 Plus eye-tracker, which tracked the dominant eye. A chin rest was used to minimise head movements, and to set a fixed distance of 70cm between participants' eyes and the VDU screen showing experimental sentences. At the start of the experiment, and during the experiment where necessary, calibration was performed using a 9-point procedure. Each trial began with a central drift correction to verify accurate calibration, followed by a square to indicate where the text would appear. Once participants accurately fixated on this square, text was presented in Arial font size 14, left-aligned on the screen, with each of the three sentences for each scenario appearing on a separate line. Participants were instructed to read each scenario carefully for comprehension, then click with the mouse when they had finished reading to proceed either to the next scenario, or a comprehension question (25% of trials). Each trial timed out after 30 seconds. The reading task took approximately 20-25 minutes to complete, and was always completed before the AQ, WASI and animations task. Autistic participants returned on a separate occasion to take part in the ADOS-2.

4.3. Results

All the analyses were pre-registered based on those used in Filik et al. (2017), and the full datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/wrk2v/).

4.3.1. Animations Task

To verify that ToM competency was compromised in our autistic sample, each verbal transcription was scored on a scale of 0–2 for accuracy, with 0 showing that participants focused on an unimportant or minor part of the interaction between triangles, 1 indicating a partially correct answer (i.e. describing the whole event but missing the critical point/mental state), and 2 showing that participants included a correct reference to the mental states of the triangles (based on the criteria outlined in Abell et al., 2000). This resulted in a total score for each participant between 0 and 8. Twenty percent of transcripts were scored by two independent raters. Inter-rater reliability across all clips was excellent according to Cicchetti's (1994) criteria (intraclass correlation = 0.85). Results showed that autistic participants were significantly impaired at describing the animations in terms of their mental states compared to the TD participants (Ms = 4.20 *vs.* 5.54, respectively; $t(47) = 2.24$, $p = 0.03$, d = 0.64).

4.3.2. Methods of Analysis (the reading paradigm)

The final target sentence for each experimental scenario was divided into three regions for analysis. The emotional response (e.g. "mean" here) was always the critical region, the word directly preceding it was always the pre-critical region, and the word/phrase that was presented after it was the post-critical region. Pre-critical and post-critical regions were identical across conditions, and the critical region was equated for length across conditions (Amused *vs.* Hurt, Ms = 7.43 *vs.* 6.88, respectively; $t(110) = 1.40$, $p = 0.165$).

	Pre-critical	**Critical**	**Post-critical**
John thought that was a	very	mean	remark.

Using a standard automatic procedure in UMass EyeDoctor 0.6.5 software, eye movements were processed so that fixations shorter than 80ms were pooled with larger adjacent fixations, fixations shorter than 40ms (and not within three characters of another fixation) were excluded, and fixations longer than 1200ms were truncated. Replicating Filik et al. (2017), five measures of reading behaviour were extracted from the eye movements: first-pass reading time, first-pass regressions out, regression path reading time, second-pass reading time, and skipping rate. First-pass reading time is the duration of gaze on a region from first entering it until first leaving it, and thus measures the costs of early text processing. First-pass regressions out measures the proportion of trials on which there is a regressive saccade from the current region to reinspect earlier text, and thus indicates the degree of difficulty readers experience during initial processing of the current region. Regression path reading time is the sum of fixations from first entering a region from the left to first leaving it on the right, and therefore indicates when readers experience difficulties processing text in a region and regress back to seek information from earlier regions. Second-pass reading time is the duration of gaze on a region when readers returned to that region for a second time (i.e. returning to a region following a saccade to the left or right). Finally, skipping rate is the proportion of trials in which a region was skipped (i.e. no fixations were made). The mean values for each of these five reading measures are shown in Table 4.3. for each region, condition and group.

Table 4.3. Mean (SE) reading time measures for autistic and TD groups across regions and conditions.

		Ironic				Literal			
		Amused		Hurt		Amused		Hurt	
		Protagonist	Victim	Protagonist	Victim	Protagonist	Victim	Protagonist	Victim
Pre-critical region									
First-pass reading time (ms)	Autistic	236 (8)	285 (16)	240 (10)	245 (11)	236 (12)	239 (12)	223 (8)	242 (9)
	TD	255 (10)	267 (10)	252 (9)	244 (9)	244 (8)	270 (11)	249 (10)	244 (10)
Second-pass reading time (ms)	Autistic	278 (27)	270 (23)	257 (18)	276 (18)	269 (20)	244 (14)	249 (19)	243 (15)
	TD	294 (22)	266 (25)	261 (22)	221 (22)	273 (27)	261 (36)	245 (21)	220 (17)
First-pass regressions out (prop)	Autistic	0.2 (0.1)	0.3 (0.1)	0.3 (0.1)	0.4 (0.1)	0.1 (0.1)	0.4 (0.1)	0.3 (0.1)	0.3 (0.1)
	TD	0.1 (0.04)	0.2 (0.1)	0.1 (0.04)	0.1 (0.04)	0.1 (0.03)	0.1 (0.04)	0.1 (0.04)	0.2 (0.1)
Regression path reading time (ms)	Autistic	354 (56)	547 (89)	550 (103)	603 (107)	609 (267)	619 (162)	606 (131)	583 (163)
	TD	310 (33)	341 (26)	415 (128)	303 (26)	271 (20)	316 (25)	334 (41)	502 (129)
Skipping rate (prop)	Autistic	0.5 (0.04)	0.4 (0.04)	0.4 (0.04)	0.5 (0.04)	0.5 (0.04)	0.4 (0.04)	0.4 (0.04)	0.4 (0.04)
	TD	0.4 (0.04)	0.4 (0.04)	0.4 (0.04)	0.5 (0.04)	0.4 (0.04)	0.5 (0.04)	0.5 (0.04)	0.5 (0.04)
Critical region									
First-pass reading time (ms)	Autistic	266 (13)	293 (16)	287 (12)	270 (13)	282 (13)	274 (11)	277 (12)	283 (12)
	TD	256 (9)	275 (11)	280 (12)	277 (9)	295 (12)	272 (10)	300 (11)	281 (10)
Second-pass reading time (ms)	Autistic	388 (45)	394 (38)	300 (32)	317 (31)	335 (30)	415 (38)	292 (27)	363 (33)
	TD	341 (60)	339 (32)	454 (76)	302 (33)	320 (37)	347 (65)	324 (34)	247 (27)
First-pass regressions out (prop)	Autistic	0.3 (0.04)	0.6 (0.1)	0.4 (0.04)	0.4 (0.05)	0.4 (0.04)	0.5 (0.04)	0.3 (0.04)	0.4 (0.1)
	TD	0.3 (0.04)	0.3 (0.04)	0.2 (0.04)	0.3 (0.04)	0.3 (0.04)	0.4 (0.04)	0.4 (0.1)	0.3 (0.04)
Regression path reading time (ms)	Autistic	749 (89)	867 (109)	613 (53)	844 (136)	934 (179)	753 (80)	704 (92)	797 (103)
	TD	531 (67)	501 (64)	465 (62)	572 (47)	599 (69)	603 (62)	594 (67)	519 (45)
Skipping rate (prop)	Autistic	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.3 (0.03)	0.3 (0.03)
	TD	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)	0.3 (0.03)	0.2 (0.03)	0.2 (0.03)	0.2 (0.03)
Post-critical region									
First-pass reading time (ms)	Autistic	334 (22)	320 (19)	351 (27)	329 (23)	364 (29)	315 (20)	373 (27)	293 (20)
	TD	348 (26)	367 (21)	351 (29)	337 (21)	327 (20)	320 (18)	316 (22)	327 (24)
Second-pass reading time (ms)	Autistic	569 (72)	441 (69)	405 (46)	505 (85)	491 (59)	465 (77)	426 (63)	331 (36)
	TD	357 (46)	410 (62)	431 (74)	470 (92)	350 (37)	414 (50)	383 (55)	441 (62)
First-pass regressions out (prop)	Autistic	0.9 (0.04)	0.8 (0.04)	0.9 (0.04)	0.8 (0.04)	0.9 (0.04)	0.9 (0.03)	0.8 (0.03)	0.9 (0.04)
	TD	0.8 (0.04)	0.7 (0.04)	0.8 (0.04)	0.8 (0.04)	0.8 (0.04)	0.9 (0.03)	0.8 (0.04)	0.8 (0.04)
Regression path reading time (ms)	Autistic	1783 (188)	1573 (138)	1458 (121)	1414 (107)	1612 (132)	1577 (180)	1379 (79)	1462 (163)
	TD	1356 (140)	1094 (88)	1060 (88)	1038 (89)	1170 (119)	1146 (90)	1185 (101)	946 (71)
Skipping rate (prop)	Autistic	0.3 (0.03)	0.3 (0.03)	0.4 (0.03)	0.3 (0.04)	0.3 (0.04)	0.3 (0.03)	0.3 (0.04)	0.3 (0.03)
	TD	0.4 (0.04)	0.3 (0.04)	0.3 (0.03)	0.3 (0.04)	0.3 (0.03)	0.4 (0.03)	0.3 (0.04)	0.3 (0.04)

Data for the three continuous measures (first-pass reading times, regression path reading times, and second-pass reading times) was log-transformed prior to analysis to increase normality due to positively skewed reading times, as recommended by Baayen et al. (2008). Eye movement data was analysed separately for each region, using the lmer function in the lme4 package for continuous data and the glmer function in the lme4 package for binary data (i.e. first-pass regressions out and skipping rate), using R [R Core Team, 2016], version 1.2.1335 (Bates et al., 2015). Deviation coding (-0.5 *vs.* 0.5) was applied to enable direct comparison between the two levels of each fixed effect. The maximal random effects structure was used, including participants and items as random effects in each model, and crossed random slopes of Group, Type, Emotion, and Perspective within items, and Type, Emotion, and Perspective within participants (as suggested by Barr, Levy, Scheepers, & Tily, 2013). When random effects led to non-convergence due to overparameterization, we removed them from the models. Details of the final models for each region/measure are available in the R script on OSF. Full statistical effects for each measure and across different regions are summarised in Table 4.4. Note that due to space constraints, only significant effects are discussed in the text here

Table 4.4. Model Estimate, Standard Error (SE) and t/z value for each measure in each region, where $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

	First-pass reading time			First-pass regressions out			Second-pass reading time			Regression path reading time			Skipping		
	Est.	*SE*	*t-value*	*Est.*	*SE*	*z-value*	*Est.*	*SE*	*t-value*	*Est.*	*SE*	*t-value*	*Est.*	*SE*	*t-value*
Pre-critical region															
Type	-0.013	0.009	-1.48	-0.114	0.168	-0.68	-0.025	0.016	-1.55	0.000	0.016	0.00	-0.027	0.082	-0.322
Perspective	0.016	0.008	2.02 *	0.543	0.168	3.24 **	-0.020	0.018	-1.11	0.054	0.021	2.54 *	0.030	0.082	0.367
Emotion	-0.009	0.008	-1.18	0.184	0.169	1.09	-0.027	0.018	-1.47	0.017	0.016	1.03	-0.081	0.082	-0.981
Group	0.031	0.022	1.44	-0.905	0.230	-3.94 ***	-0.017	0.026	-0.68	-0.075	0.029	-2.60 *	-0.099	0.185	-0.536
Type*Perspective	-0.015	0.016	-0.94	0.254	0.335	0.76	0.001	0.032	0.02	-0.009	0.033	-0.28	0.116	0.165	0.706
Type*Emotion	0.006	0.016	0.41	0.344	0.336	1.03	0.003	0.032	0.09	0.010	0.033	0.32	-0.070	0.165	-0.423
Perspective*Emotion	-0.025	0.016	-1.58	-0.115	0.335	-0.34	0.021	0.032	0.66	-0.054	0.033	-1.66	-0.245	0.165	-1.484
Type*Group	0.029	0.016	1.87	-0.264	0.335	-0.79	-0.002	0.032	-0.08	0.007	0.033	0.21	-0.009	0.165	-0.053
Perspective*Group	-0.017	0.016	-1.06	0.011	0.335	0.03	-0.035	0.032	-1.08	-0.054	0.042	-1.28	-0.179	0.165	-1.090
Emotion*Group	-0.015	0.016	-0.96	0.085	0.337	0.25	-0.047	0.037	-1.29	0.000	0.033	-0.01	-0.247	0.165	-1.497
Type*Perspective*Emotion	0.022	0.031	0.70	-0.038	0.671	-0.06	0.007	0.065	0.10	-0.005	0.065	-0.08	0.380	0.330	1.153
Type*Perspective*Group	0.032	0.031	1.02	0.617	0.670	0.92	0.041	0.064	0.64	0.068	0.065	1.05	-0.207	0.329	-0.629
Type*Emotion*Group	-0.025	0.031	-0.79	1.392	0.672	2.07 *	0.026	0.064	0.40	0.098	0.065	1.51	-0.157	0.329	-0.477
Perspective*Emotion*Group	-0.033	0.032	-1.06	0.577	0.672	0.86	-0.032	0.064	-0.50	0.032	0.065	0.49	0.519	0.329	1.577
Type*Perspective*Emotion*Group	-0.112	0.063	-1.78	1.359	1.341	1.01	0.022	0.129	0.17	0.054	0.130	0.42	0.840	0.659	1.275
Critical region															
Type	0.012	0.008	1.49	0.116	0.117	0.99	-0.016	0.020	-0.798	0.030	0.015	1.98 *	-0.065	0.111	-0.587
Perspective	-0.003	0.008	-0.36	0.228	0.155	1.47	-0.002	0.020	-0.110	0.026	0.018	1.47	0.030	0.100	0.297
Emotion	0.003	0.010	0.30	-0.142	0.118	-1.20	-0.022	0.020	-1.061	-0.012	0.015	-0.80	-0.027	0.158	-0.172
Group	0.010	0.025	0.38	-0.565	0.326	-1.73	-0.015	0.034	-0.454	-0.092	0.040	-2.33 *	0.134	0.207	0.646
Type*Perspective	-0.022	0.016	-1.44	-0.174	0.234	-0.74	0.037	0.041	0.912	-0.043	0.030	-1.43	-0.031	0.200	-0.156
Type*Emotion	-0.010	0.016	-0.64	-0.035	0.235	-0.15	0.009	0.041	0.229	-0.004	0.030	-0.14	-0.325	0.206	-1.579
Perspective*Emotion	-0.023	0.015	-1.49	-0.392	0.235	-1.67	-0.062	0.041	-1.522	-0.009	0.030	-0.29	-0.165	0.200	-0.822
Type*Group	0.018	0.016	1.16	0.438	0.235	1.86	-0.070	0.041	-1.735	0.041	0.030	1.36	0.148	0.200	0.739
Perspective*Group	-0.013	0.016	-0.86	-0.210	0.283	-0.74	-0.087	0.041	-2.14*	-0.025	0.036	-0.70	0.228	0.200	1.140
Emotion*Group	0.022	0.016	1.43	0.081	0.235	0.34	0.061	0.041	1.495	0.029	0.030	0.97	0.271	0.251	1.079
Type*Perspective*Emotion	0.052	0.031	1.68	-0.088	0.471	-0.19	0.051	0.081	0.636	-0.004	0.060	-0.07	-0.550	0.400	-1.374
Type*Perspective*Group	-0.032	0.031	-1.02	-0.231	0.469	-0.49	-0.039	0.082	-0.479	-0.034	0.060	-0.56	0.354	0.399	0.886
Type*Emotion*Group	0.016	0.031	0.50	-0.078	0.469	-0.17	-0.110	0.082	-1.352	-0.074	0.060	-1.23	0.190	0.399	0.476
Perspective*Emotion*Group	0.018	0.031	0.59	0.846	0.469	1.80	-0.122	0.082	-1.499	0.060	0.060	0.99	-0.420	0.400	-1.051
Type*Perspective*Emotion*Group	-0.067	0.062	-1.08	-2.320	0.940	-2.47 *	0.118	0.162	0.728	-0.180	0.120	-1.50	-0.856	0.799	-1.071
Post-critical region															
Type	-0.005	0.014	-0.38	0.144	0.145	0.99	-0.016	0.029	-0.54	0.004	0.017	0.23	0.04	0.12	0.33
Perspective	-0.002	0.011	-0.17	0.007	0.145	0.05	-0.013	0.037	-0.35	-0.010	0.017	-0.58	-0.05	0.14	-0.33
Emotion	-0.010	0.011	-0.98	-0.142	0.165	-0.86	0.020	0.029	0.69	-0.036	0.017	-2.09 *	-0.14	0.10	-1.43
Group	0.008	0.039	0.22	-0.239	0.287	-0.84	0.002	0.047	0.05	-0.108	0.061	-1.77	0.11	0.32	0.35
Type*Perspective	-0.010	0.021	-0.46	0.184	0.290	0.64	0.011	0.058	0.18	0.008	0.035	0.24	0.21	0.20	1.04
Type*Emotion	0.006	0.021	0.30	-0.124	0.289	-0.43	-0.068	0.057	-1.19	0.023	0.035	0.66	0.05	0.20	0.23
Perspective*Emotion	-0.024	0.021	-1.12	0.046	0.289	0.16	0.040	0.058	0.69	-0.012	0.035	-0.36	-0.11	0.20	-0.53
Type*Group	-0.031	0.026	-1.20	-0.058	0.290	-0.20	0.005	0.058	0.09	-0.013	0.035	-0.38	0.04	0.23	0.16
Perspective*Group	0.028	0.021	1.34	0.065	0.291	0.22	0.070	0.074	0.96	0.008	0.035	0.23	-0.10	0.25	-0.40
Emotion*Group	-0.024	0.021	-1.13	-0.156	0.289	-0.54	0.086	0.058	1.49	-0.014	0.035	-0.39	-0.33	0.20	-1.66
Type*Perspective*Emotion	0.008	0.042	0.19	-1.091	0.579	-1.89	-0.135	0.115	-1.17	-0.083	0.070	-1.19	0.05	0.39	0.14
Type*Perspective*Group	-0.005	0.042	-0.12	0.207	0.578	0.36	0.089	0.116	0.77	0.026	0.069	0.37	-0.10	0.39	-0.25
Type*Emotion*Group	0.019	0.042	0.46	-0.061	0.576	-0.11	-0.012	0.115	-0.10	0.054	0.069	0.79	-0.81	0.39	-2.06 *
Perspective*Emotion*Group	0.006	0.042	0.14	-0.130	0.578	-0.23	-0.051	0.116	-0.44	-0.004	0.070	-0.05	-0.28	0.39	-0.72
Type*Perspective*Emotion*Group	0.123	0.084	1.46	-2.578	1.154	-2.24 *	0.178	0.230	0.77	-0.014	0.139	-0.10	1..66	0.79	2.10 *

4.3.3. Eye movmeent data

Pre-critical word region: In this region, there was a significant effect of Perspective in first-pass reading times (protagonist vs. victim: M = 242.14 vs. 254.18, SE = 3.23 vs. 3.98; Cohen's d = 0.25), first-pass regressions out (M = 0.17 vs. 0.25, SE = 0.02 vs. 0.02; Cohen's d = 0.20) and regression path reading times (M= 430.65 vs. 474.34, SE= 40.64 vs. 37.30; Cohen's d = 0.16), showing that participants had longer reading times and made more regressions out when the target sentence depicted the victim's perspective compared to the protagonist's perspective. This pattern replicates the results obtained by Filik et al. (2017), and suggests that readers found it easier to adopt the protagonist's perspective when processing these narratives.

There was also a significant effect of Group in first-pass regressions out (autistic *vs.* TD group: *M* = 560.17 *vs.* 349.42, *SE* = 50.08 *vs.* 24.52; Cohen's *d* = 0.33) and regression path reading times (autistic *vs.* TD group: *M* = 0.28 *vs.* 0.14, *SE* = 0.02 *vs.* 0.01; Cohen's *d* = 0.23), revealing increased likelihood of regressions, and longer regression path reading times in the autistic group compared to the TD group (as seen in previous eye-tracking research). In addition, the Group × Emotion × Type interaction was significant in this region on the first-pass regressions out measure (Cohen's *d* = 0.50), however none of the post-hoc comparisons reached significance when tested (*zs* < 1.17, *ps* > 0.238).

Critical word region: In this critical region, there was a significant effect of Group in regression path reading time (Cohen's d = 0.25), as participants in the autistic group had longer reading times (M= 783.53, SE= 39.66) compared to the TD group (M = 548.67, SE = 21.40), mirroring the patterns seen in the pre-critical region and previous eye-tracking reading research. There was also a significant effect of Type in regression path reading time (Cohen's d = 0.25), reflecting longer reading times in the literal criticism condition (M= 685.83, SE = 33.54) compared to the ironic criticism condition (M = 640.83, SE = 29.20).

Importantly, analysis of first-pass regressions out revealed a significant 4-way interaction between Group, Emotion, Type, and Perspective (see Figure 4.1.; Cohen's *d* = 0.92). To explore this effect further, we tested the Emotion x Type x Perspective interaction separately for each Group. The TD group showed a significant effect of Type (literal > ironic; *Est.* = 0.33, *SE* = 0.17, $z = 1.96$, $p = 0.050$), and the Emotion x Type x Perspective interaction was marginally significant (*Est.*= -1.27, *SE* = 0.67, $z = -1.89$, $p = 0.058$). To follow up this three-way interaction in the TD group, we first separated the data by Emotion (thus replicating Experiments 1 and 2 in Filik et al., 2017) and found a significant Type x Perspective interaction in the hurt condition (*Est.* = -1.03, *SE* = 0.46, $z = -2.23$, $p = 0.026$), but not in the amused condition (*Est.* = 0.36, *SE* = 0.49, $z = 0.74$, $p = 0.460$). Post-hoc comparisons revealed that TD participants made more regressions out when the protagonist had used literal criticism to hurt the victim (*M* = 0.36, *SE* = 0.05) compared to when the protagonist used ironic criticism to hurt the victim (*M* = 0.23, *SE* = 0.04; *Est*. = 0.71, *SE* = 0.32, $z = 2.22$, $p = 0.026$). There was no difference between the two types of criticism when the emotional reaction was described from the victim's perspective (*Est.* = -0.10, *SE* = 0.34, $z = -0.30$, $p = 0.770$). This pattern suggests that participants in the TD group expected the protagonist to intend more hurt when they used ironic than literal criticism (i.e. they found it more difficult to integrate a hurt emotion following literal criticism), but were equally likely to expect a hurt response for the victim following both types of criticism.

In contrast, the three-way interaction did not reach significance in the autistic group (*Est.* = 1.08, *SE* = 0.65, z = 1.66, p = 0.097)[5]; only the overall effect of Perspective (victim > protagonist; *Est.* = 0.33, *SE* = 0.16, z = 2.01, p = 0.044) and the two-way Emotion x Perspective interaction were significant (*Est.* = -0.87, *SE* = 0.33, z = -2.67, p = 0.007). Follow up analyses for this two-way interaction revealed that autistic participants made more regressions out from the critical region when the victim found the comment amusing (*M* = 0.45, *SE* = 0.02) compared to when the protagonist intended the comment to be amusing (*M* = 0.37, *SE* = 0.02; *Est.* = 0.77, *SE* = 0.23, z = 3.37, p < 0.001). There was no difference between the two perspectives when the comment was described as hurtful (*Est.* = -0.06, *SE* = 0.23, z = -0.24, p = 0.814). This pattern suggests that autistic participants successfully tracked the two characters' perspectives, and were immediately sensitive to the victim's expected emotions following the criticism (i.e. they found it more difficult to integrate an amused emotion), but importantly did not distinguish literal and ironic criticism.

Finally, analysis of second-pass reading time revealed a significant Group x Perspective interaction (Cohen's d = 0.35), however none of the post-hoc comparisons reached significance when tested (*ts* < 1.56, *ps* > 0.119).

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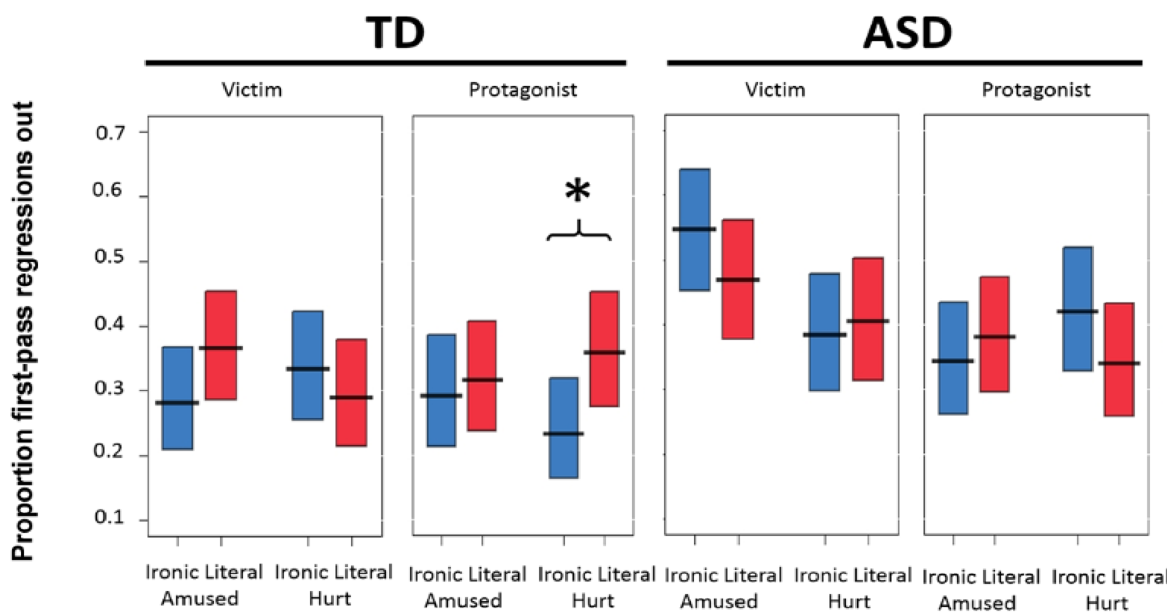
[5]An exploratory analysis examined the effects underlying this marginal 4-way interaction, as in the TD group, but the Type x Perspective interaction was not significant in either the hurt or the amused condition (*zs* < 0.55, *ps* > 0.23), and none of the post-hoc comparisons of Type for each Perspective condition reached significance (*zs* < 0.38, *ps* > 0.24).



<u>Figure 4.1.:</u> Proportion of first-pass regressions out from the critical region, with a horizontal line reflecting the condition mean, and a rectangle representing the Bayesian highest density interval. * indicates a significant difference between ironic and literal conditions.

Post-critical word region: In this region, there was a main effect of Emotion in regression path reading times (Cohen's d = 0.10), with longer reading times when the character was described as feeling amused (M = 1402.89, SD = 1606.76) compared to when the character was described as feeling hurt (M = 1245.48, SD = 1198.3).

Similar to the critical region, analysis of first-pass regressions out in this post-critical region revealed a significant 4-way interaction between Group, Emotion, Type, and Perspective (see Figure 4.2.; Cohen's *d* = 0.82). To follow up this interaction, we again tested the Emotion x Type x Perspective interaction separately for each Group. In the TD group, the Type x Perspective x Emotion interaction was significant (*Est.* = -2.39, *SE* = 0.84, *z* = -2.85, *p* = 0.004). As before, follow-up analyses were run separately for each emotion, and revealed a significant Type x Perspective interaction in the amused condition (*Est.* = 1.38, $SE = 0.61$, $z = 2.25$, $p = 0.024$), but not in the hurt condition (*Est.* = -0.90, $SE = 0.57$, $z = -1.56$, $p = 0.118$). Post-hoc comparisons revealed that TD participants made more regressions out when the victim perceived the literal criticism as amusing ($M = 0.87$, $SD = 0.34$) compared to when the victim perceived the ironic criticism as amusing ($M = 0.73$, $SD = 0.45$; *Est*. = 0.93, $SE = 0.48$, $z = 1.94$, $p = 0.052$). There was no difference between the two types of criticism when the emotional reaction was described from the protagonist's perspective (*Est.* = -0.47, $SE = 0.41$, $z = -1.16$, $p = 0.245$). Taken together, this suggests that TD participants expected the victim to feel more amusement when the protagonist used ironic than literal criticism (i.e. they found it more difficult to integrate an amused emotion following literal criticism), but were equally likely to expect the protagonist to intend an amusing emotion following both types of criticism. None of the effects reached significance in the autistic group ($zs < 0.81$, $ps > 0.420$).

There was also a significant 4-way interaction (Type x Perspective x Emotion x Group) in skipping rates (Cohen's $d = 0.52$), however none of the post-hoc comparisons reached significance when tested ($zs < 1.52$, $ps > 0.130$).

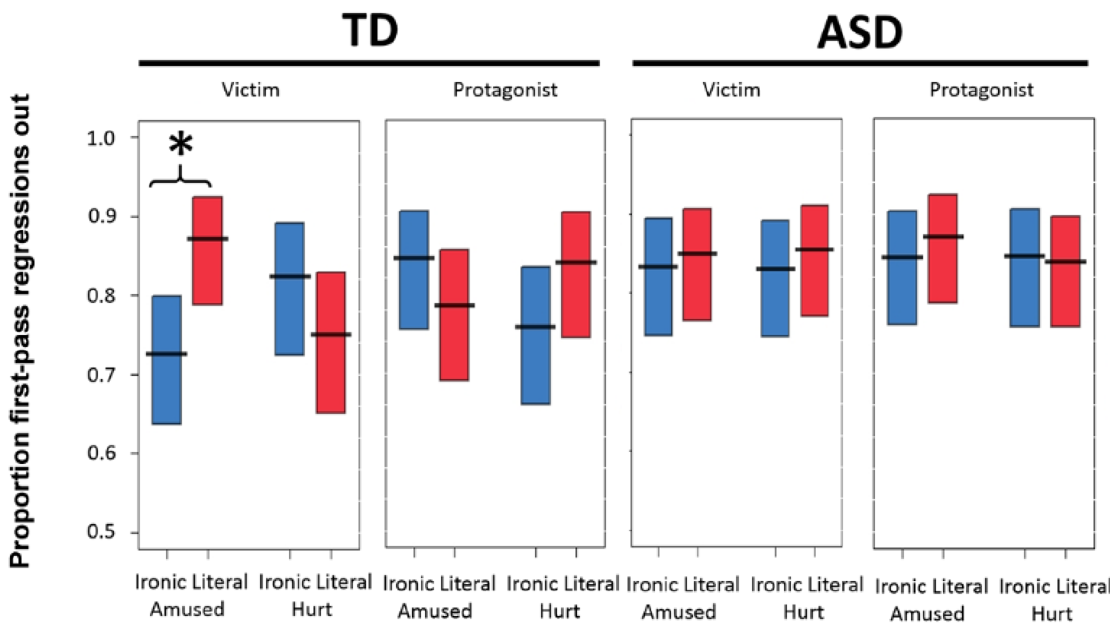


Figure 4.2. Proportion of first-pass regressions out from the post-critical region, with a horizontal line reflecting the condition mean, and a rectangle representing the Bayesian highest density interval. * indicates a significant difference between ironic and literal conditions.

4.4. Discussion

In this paper, we sought to understand how autistic adults process the emotional responses relating to irony in real-time. Specifically, we examined whether and how autistic adults keep track of the perspective and emotional intentions of the characters in the story (i.e. the protagonist and the victim), following ironic criticism. In a pre-registered experiment, autistic and non-autistic adult participants were eye-tracked while they read short narratives in which a protagonist criticized the actions of a victim using either literal (e.g. “That was horrendous parking”) or ironic (e.g. “That was fantastic parking") criticism. Subsequently, the victim was described as feeling hurt or amused, or the protagonist was described as intending to inflict hurt or amusement by this comment. Reading patterns (i.e. measures of reading time and incidence of regressions) indicated when readers experienced difficulty integrating the emotion words in each context.

Our results were similar to the key findings from Filik et al. (2017), thus validating the task as a sensitive measure of irony comprehension and emotion tracking. Firstly, type of criticism influenced reading on the critical word, with longer regression path reading times following literal than ironic criticism, indicating that readers found it easier to integrate an emotional response in the ironic condition. This pattern is consistent with previous research that has suggested a link between figurative language and emotional experiences, hence individuals may be more likely to associate ironic language with emotional responses, and consequently find it easier to integrate an emotional response following the ironic comment (Gibbs, Leggitt, & Turner, 2002; Knickerbocker, Johnson, & Altarriba, 2015). Secondly, readers had longer first-pass and regression path reading times and made more regressions out of the pre-critical region when taking the victim's perspective compared to the protagonist's perspective, which suggests that they found it easier to process text from the protagonist's perspective. However, it is worth noting that in the victim condition, participants had to switch between the characters' perspectives twice (victim -> protagonist -> victim), whereas in the protagonist's condition participants only had to switch perspectives once (victim -> protagonist -> protagonist). Hence, longer reading times and more regressions in the victim condition could simply be due to the greater processing costs of switching between perspectives and working memory load (Black, Turner, & Bower, 1979).

More importantly, data from the TD group support the two-stage account put forward by Filik et al. In the critical region, TD individuals found it easier to integrate a hurt response when the protagonist had intended to hurt the victim by making an ironic comment (i.e. they made fewer regressions out from a hurt emotion word following ironic than literal criticism). This replicates the findings of Filik et al. (2017), showing that participants initially found it easier to integrate a hurt response following ironic criticism than literal criticism. Subsequently, in the post-critical region, readers experienced difficulties integrating an amused response for the victim following a literal comment, but processed the amused responses more easily following an ironic comment (i.e. they made more regressions out from an amused emotion word following literal than ironic criticism). This pattern is also consistent with Filik et al.'s findings, showing that processing emotional responses to irony involves two stages: readers initially expect the victim to feel more hurt following ironic criticism than following literal criticism, but that the victim will eventually find it more amusing than hurtful. The findings also provide further evidence for the tinge hypothesis, showing that sarcastic criticism is ultimately perceived as less negative and funnier (Dews & Winner, 1995; Dews et al., 1995). The fact that these emotional expectation effects were specific to the victim, and not the protagonist, shows that TD participants successfully tracked the different character perspectives in real time, and were sensitive to the distinct intentions and feelings that each might experience.

Interestingly, evidence for this two-stage process was absent in the autistic group; group modulated the 3-way effects between Type, Perspective and Emotion on first-pass regressions out. In the critical region, autistic participants distinguished emotional responses for the victim and protagonist (i.e. they found it harder to integrate when the victim found the comment amusing compared to when the protagonist intended the comment to be amusing), but did not discriminate between the two types of criticism. Thus, participants showed some evidence of tracking emotional responses for the two characters, but criticism delivered ironically was interpreted in the same way as literal criticism, which suggests that readers did not infer the intended negative meaning for the ironic comment, and thus did not differentiate between the types of criticism.

Reading behaviours in the post-critical region were not influenced by any of our experimental manipulations in the autistic group. It is possible that this absent or reduced propensity to make perspective-relevant emotional inferences based on ironic criticism relates to the autistic group’s significantly impaired ability to infer others’ mental states (as measured by the animations task here; Abell et al., 2000). The narrative scenarios tested in the current study relied heavily on readers making rapid inferences about other peoples’ mental states, extracting their intentions and associating them with appropriate emotions. Since our autistic sample were also impaired at inferring intentions for inanimate triangles and previous research has demonstrated an intact ability to comprehend basic irony in autistic adults (Au Yeung et al., 2015), the current findings could suggest that autistic people experienced a specific difficulty taking into account the communicative intentions of the protagonist (i.e. using ToM). Consequently, they may have struggled to appropriately anticipate the emotional responses to the ironic comment. This finding supports previous literature, which has shown impairments in representing the mental states of others in autism (Agostino, Im-Bolter, Stefanatos, & Dennis, 2017; Baron-Cohen, Tager-Flusberg, & Cohen, 1994; Baron-Cohen, 1997; Frith, 2003; Hamilton, 2009; Happé, 1994; Jolliffe, & Baron-Cohen 1999; Kapogianni, 2016; Sabbagh, 1999), including intentions (for discussion, see Williams & Happé, 2010). Ideally, this causal relationship would be tested by correlating ToM scores with the reading measures during irony comprehension. Unfortunately, these post-hoc analyses were not possible in the current study due to the relatively small sample size (25 autistic adults and 24 TD adults), and restricted range of variability (range: 0-8 in 9 discrete values; see Bland & Altman, 2011) and non-normal distribution of ToM scores obtained from the animations task (coW = 0.92477, $p < .001$; using the Shapiro-Wilk normality test). However, future research should investigate whether and how ToM abilities predict emotion understanding in ironic language (See Bland & Altman, 2011).

Another possible explanation for the autistic group's apparent insensitivity to the emotional responses to irony is their reduced knowledge about the functional use of verbal irony. Previously it has been argued that as well as ToM, general conceptual knowledge of irony and its affective processes are necessary for comprehending verbal irony and appreciating its social functions, such as diluting the negative comment through humour and condemning the undesirable behavior at the same time (Akimoto, Sugiura, Yomogida, Miyauchi, Miyazawa, & Kawashima, 2014; Dews & Winner, 1995; Harris & Pexman, 2003; Lucariello, 1994; Pexman & Glenwright, 2007). For example, Pexman et al. (2011) demonstrated that autistic children had an intact ability to process ironic comments, but were less likely than TD children to rate them as more humorous than literal comments. The authors thus concluded that autistic children may struggle to understand the social functions of using irony. This topic has received little attention in autism research, and has never been examined in an adult autistic sample, so future research should focus on how autistic individuals perceive verbal irony and its associated emotional processes.

Taken together, the results also provide evidence for both the complex information processing disorder account and the predictive coding theory of autism, since both theories suggest that under high cognitive load, autistic individuals struggle with processing information in context. For example, the complex information processing theory suggests that autistic individuals struggle with integrating information when multiple sources are involved (Minshew & Goldstein, 1998), and the predictive coding theory proposes that autistic individuals struggle with ignoring the bottom up errors and making predictions due to meta learning impairments, which is more pronounced in complex and dynamic situations (Van de Cruys et al., 2014). In this task, as well as comprehending irony, participants were required to switch between perspectives, keep track of the characters' intentions and integrate the emotional related cues and finally and crucially interpret the final sentence as part of the discourse to infer the meaning and the emotional states, which is likely to have loaded cognitive capacities and thus could explain why autistic people were impaired at representing the emotional states of the characters. However, it would be informative to for future studies to explore whether any of these processes are specifically associated with higher cognitive costs or whether it is the combination that makes it cognitively demanding? Whilst the results are interesting and informative, we acknowledge the potential limitation of sample size;

we simply may not have had sufficient power to accurately detect the 3- and 4-way interaction effects in our experiment (particularly due to wide heterogeneity among the autistic group). Our sample size was chosen *a priori* to achieve comparable participant numbers in each group to the total sample size used in each experiment in Filik et al. (2017; N = 28), and to match or exceed the sample size used for previous studies that have used eye-tracking to compare reading in autistic and TD adults. In the current study, detecting a significant 4-way interaction with the significance level of α=.05 on 80% of occasions (as suggested by Cohen, 1988) would have needed a minimum of 90 participants (calculated using the *simr* package in R; Green & MacLeod, 2016). The current sample size yields an estimated power of 56%. It would not be feasible to recruit and test ~45 autism individuals, as well as ~45 age- and IQ-matched controls, using the complex methods we used, given the difficulties associated with recruiting and testing autistic people (i.e. autism affects only 1% of the population and over half of autistic individuals have an intellectual impairment that would prevent them from taking part in the kind of study that we conducted). Importantly, the results in the TD group were similar to the patterns seen in Filik et al. (2017). Moreover, since the 4-way interaction emerged on two consecutive regions of the same eye-tracking measure, and the atypical processing in the autistic group was revealed on both, we can feel relatively confident that the reported findings are reliable. Nevertheless, as a field, research on autism should continue to aim for larger sample sizes, ideally recruiting participants with a diverse representation on the autism spectrum to ensure generalizability of results.

Finally, our experiment revealed group differences in overall reading time, with adults in the autistic group incurring longer regression path reading times and making more regressions out from the critical and pre-critical regions compared to the TD control group. This pattern adds to the fairly consistent finding from eye-tracking research to date, suggesting that autistic people employ a more cautious reading strategy, and are more likely to re-read text to verify understanding of the intended meaning (Au-Yeung et al., 2015; Black et al., 2018; 2019; Ferguson et al., 2019; Howard et al., 2017a,b,c; Sansosti, Was, Rawson, & Remaklus, 2013). A similar pattern has been reported in neuroimaging research, which suggests that autistic individuals show traces of hyper-lexicality, meaning that they focus more on the meaning of words and individual sentences and less on using mental imagery to build a coherent representation of discourse while processing discourse online (Just, Cherkassky, Keller, & Minshew, 2004). Hence, our data adds to the body of evidence showing that autistic individuals invest more resources to build representations of text- they re-inspect it more frequently to gain confidence in the way they have interpreted the text, perhaps due to facing more difficulties while integrating the information (e.g. Just et al., 2004; Kana, Keller, Cherkassky, Minshew, & Just, 2006).

In conclusion, the results of the present study were similar to those in Filik et al. (2017) in showing that TD individuals comprehend emotional responses to irony following a two-stage process. Readers initially expected the protagonist to intend more hurt by using an ironic comment, but at a later stage expected the victim be more amused by an ironic comment. Thus, TD readers built a mental presentation of the text online, and updated it in real time. Importantly, autistic individuals did not differentiate between the emotional responses for victims or protagonists following ironic *vs.* literal criticism. We think this difficulty could be associated with more general impairments in representing the communicative intentions of the protagonist (i.e. ToM), and a reduced/atypical awareness of the social functions of irony and its affective processes. Taken together, our findings suggest that delivering criticism using irony has a less negative impact on the recipient. Therefore, understanding its emotional impact has important implications for maintaining successful real-life social interactions. Since this is the first study investigating this topic in autistic adults, future research is needed to confirm our findings and further explore the explicit emotional process of using irony in autistic people.

Chapter 5: Perspective influences eye movements during real-life conversation: Mentalising about self *vs* others in autism

An edited version of this chapter has now been accepted for publication: Barzy, M., Ferguson, H.J., & Williams, D. (accepted for publication in *Autism*). Perspective influences eye movements during real-life conversation: Mentalising about self *vs* others in autism.

Perspective influences eye movements during real-life conversation:

Mentalising about self *vs* others in autism

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Author note: All analysis procedures were pre-registered, and the full experimental materials, datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/g485j/).

Lay Summary: Previous lab-based studies suggest that autistic individuals are less attentive to social aspects of their environment. In our study we recorded the eye movements of autistic and typically developing adults while they engaged in a real-life social interaction with a partner. Results showed that autistic adults were less likely than typically developing adults to look at the experimenter's face, and instead were more likely to look at the background. Moreover, the topic of conversation (talking about self vs others) modulated the patterns of eye movements in autistic and non-autistic adults. Overall, people spent less time looking at their conversation partner's eyes and face, and more time looking at the background, when talking about an unfamiliar other compared to when talking about themselves. This pattern was magnified among autistic adults. We conclude that allocating attention to social information during conversation is cognitively effortful, but this can be mitigated when the topic of conversation is familiar.

5.1. Abstract

Socio-communication is profoundly impaired among autistic individuals. Difficulties representing others' mental states have been linked to modulations of gaze and speech, which have also been shown to be impaired in autism. Despite these observed impairments in 'real-world' communicative settings, research has mostly focused on lab-based experiments, where the language is highly structured. In a pre-registered experiment, we recorded eye movements and verbal responses while adults (N=50) engaged in a real-life conversation. Conversation topic either related to the self, a familiar other, or an unfamiliar other (e.g. "Tell me who is your/your mother's/Marina's favourite celebrity and why?”). Results are in line previous work, showing reduced attention to socially-relevant information among autistic participants (i.e. less time looking at the experimenter’s face, and more time looking around the background), compared to typically-developing controls. Importantly, perspective modulated social attention in both groups; talking about an unfamiliar other reduced attention to potentially distracting or resource-demanding social information, and increased looks to non-social background. Social attention did not differ between self and familiar other contexts- reflecting greater shared knowledge for familiar/similar others. Autistic participants spent more time looking at the background when talking about an unfamiliar other *vs* themselves. Future research should investigate the cognitive mechanisms underlying this effect.

Keywords: Perspective taking, Autism, Eye-Tracking, Real-Life Social Interactions, Topic of Conversation

Autism spectrum disorder (ASD) is a pervasive neurodevelopmental condition, diagnosed on the basis of impairments in social-communication and a restricted and repetitive pattern of behaviour and interests (American Psychiatric Association, 2013). Two key cognitive-level mechanisms that underpin social-communication ability are theory of mind (ToM) and social attention (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Kalandadze, Norbury, Nærland, & Næss, 2018). ToM is the ability to represent the mental states of the self and others in order to explain and predict behaviour (i.e. mentalising; Premack & Woodruff, 1978). It is widely believed to be impaired/diminished among autistic people[1] (Baron-Cohen, Leslie, & Frith, 1985; Happé, 1994; Moran et al., 2011). Social attention refers to the ability and motivation to attend to, as well as coordinate attention with, a social partner during interaction (e.g., through joint attention, use of non-verbal gestures, including eye contact, and orientation and focusing of the visual system toward one's partner), and is also known to be atypical in autism (Chita-Tegmark, 2016). Social attention can be modulated through eye gaze, because we send and receive a great deal of social information through use and shifting of gaze (Cañigueral & Hamilton, 2019). It is particularly notable, therefore, that social-communication and ToM impairments in autism are associated with an atypical social attention distribution (Swettenham et al., 1998; Senju, 2013; von dem Hagen, Stoyanova, Rowe, Baron-Cohen, & Calder, 2013).

Reduced eye gaze to social stimuli during experimental tasks has been reported from early in development among autistic people (Bhat, Galloway, & Landa, 2010; Chawarska, Macari, & Shic, 2013; Dawson, 1991). In particular, several studies have indicated that autistic individuals are less attentive to social stimuli- and faces, in particular- than their typically developing (TD) counterparts (Bird, Press, & Richardson, 2011; Nakano et al., 2010; Riby & Hancock, 2009; von Hofsten, Uhlig, Adell, & Kochukhova, 2009). Furthermore, eye-tracking research shows that social attention in autism is associated with reduced gaze to the eyes and increased gaze to the mouth while scanning faces online, which is opposite to what tends to be observed in TD individuals (Chita-Tegmark, 2016; Corden, Chilvers, & Skuse, 2008; Guillon, Hadjikhani, Baduel, & Rogé, 2014). However, more recent literature has indicated comparable patterns of social attention towards the eyes and faces among TD and autistic individuals (Bar-Haim, Shulman, Lamy, & Reuveni, 2006; Fletcher-Watson, Findlay, Leekam, & Benson, 2008; Van Der Geest, Kemner, Verbaten, & Van Engeland, 2002). The mixed findings about this aspect of social attention in ASD may arise from the fact that different types of stimuli have been used across the studies (ranging from images of isolated faces, static cartoon/natural images, dynamic videos etc.). Plus, in almost all of these studies, the social partner/stimuli was not physically present, making it hard to generalise these results to everyday, real-world social interactions. It is, of course, essential to be able to generalise from experimental results to real-world behaviour, especially since the difficulties that autistic individuals experience with social interaction have been attributed to a specific difficulty *using* language appropriately in social contexts, rather more general cognitive impairments (Tager-Flusberg, 1999). Arguably, the paucity of research on how autistic individuals navigate face-to-face social interactions has hindered progress in the field.

The only study that we are aware of to employ eye-tracking methods to investigate real-world social interactions among autistic adults was conducted by Freeth and Bugembe (2019). They found that autistic adults were less likely to look at their social partner's face than were TD adults, especially when the partner's gaze was directed at them (Freeth, & Bugembe, 2019). In line with previous studies, Freeth and Bugembe also found that non-autistic individuals had increased fixations on the eyes of their social partner compared to their mouth, but this was not the case in autism (Chita-Tegmark, 2016). Yet, evidence from studies of individual differences in the general population is not entirely consistent with the evidence provided by Freeth and Bugembe's case-control study. Neither, Vabalas and Freeth (2016), nor Freeth et al. (2013), found a significant correlation between the number of autistic traits self-reported by neurotypical adults and the number of looks to the experimenter during a live interaction with a social partner (Freeth, Foulsham, & Kingstone, 2013). On the other hand, Vabalas and Freeth (2016) did find that participants with higher numbers of autistic traits manifested in a reduced tendedency to explore the scene visually. The authors concluded that this indicates a local visual processing bias in autistic individuals, as they pay more attention to the details of specific areas in the scene, and consequently visually explore the scenes less.

Recent evidence suggests that the pattern of eye movements during real-life interactions is further modulated by topic of conversation among autistic people. For example, Nadig et al. (2010) showed that autistic individuals were more likely to look at the face of their conversation partner when talking about a topic of circumscribed interest than when talking about a general topic that they were not especially interested in. Likewise, Hutchins and Brien (2016) observed that, during a Skype conversation, autistic children were less likely to look at the experimenter's eyes when talking about emotions than when they were discussing general topics concerning occupations and lifestyles. Perhaps discussing a familiar topic or a topic that does not involve emotion understanding (i.e., mentalising) with a social partner involves a lower processing cost than does discussion of an unfamiliar topic or a topic that requires emotion understanding. This is in line with numerous studies that have found higher levels of gaze aversion when autistic and TD individuals reply to questions that are difficult in nature (i.e. involve a high processing load; Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002; Doherty-Sneddon, & Phelps, 2005; Glenberg, Schroeder, & Robertson, 1998). This is important because social-communication skills in autistic people may be scaffolded when discussing topics that are familiar to them, or generally easy to process.

In the current study, we explored this by comparing eye movements during a discussion between the participant and the experimenter about the participant themselves, a person well-known to the participant, and a person that was unfamiliar to the participant. Previous research suggests that friends may have a better understanding of each others' minds than strangers (e.g. Savitsky, Keysar, Epley, Carter, & Swanson, 2011), and that the quality of social interaction is enhanced between pairs of friends *vs* strangers (Pollman & Krahmer, 2017). Thus, we reasoned that discussions about the self and a familiar other might yield more typical patterns of eye gaze among autistic participants than discussions about an unfamiliar other, because self-relevant information is easier to process and structures cognition better than information relevant to others (especially unfamiliar others), among both TD people (Kuiper, & Rogers, 1979; Sui, & Humphreys, 2015; Symons, & Johnson, 1997) and autistic people (e.g., Lind, Williams, Nicholson, Grainger, & Carruthers, 2019; Williams, Nicholson, & Grainger, 2018; Grainger, Williams, & Lind, 2014).

It is clear that there is a lack of research comparing how mentalising (i.e. representing others' mental states) during real-life social interactions influences the eye gaze behaviour in autistic and TD individuals. Hence, this study was set to investigate two objectives. The first aim was to compare the patterns of eye movements between autistic and TD individuals during real-life social interactions, where the communication partner was physically present and language was unstructured. The second aim was to establish the extent to which gaze to social and non-social aspects of the environment differ when autistic and TD participants are prompted to think about themselves, a familiar other person, and an unfamiliar other person. We believe this would allow us to compare the processing costs of mentalising about the self and others in autism. The comparison between self, a familiar and an unfamiliar other would also help us to gain a better understanding of self-referential processing in autism.

In this study, participants first read a short scenario describing a male or a female 'unfamiliar' character. The scenarios were identical in terms of content (i.e. the characters' hobbies, occupation etc.), differing only in the gender of the main character (selected to match each participants' gender). Relevant cues, but not necessary the answers,were given in the scenarios so participants had to think about the characters' preferences, characteristics, etc. to be able to answer the questions about the unfamiliar other. Afterwards, participants engaged in a semi-structured conversation with the experimenter, answering questions about everyday life activities. These questions were either related to the participant themselves, or to someone the participant knew (e.g. one of their parents or a sibling), or to the character in the scenario the participant had just read (e.g. "Tell me somewhere you/your mother/Marina–the character in the scenario–would like to go over Christmas and why you think that?”). These questions were designed to elicit a short dialogue between participants and the experimenter also to encourage participants to mentalise about different people. Participants’ answers and eye movements were recorded using a mobile eye-tracker and a voice recorder.

Previous eye-tracking research into social attention in autism has revealed mixed findings, partly due to methodological differences (i.e., physical presence of social partner, diagnostic criteria for ASD). On one hand, lab-based experimental tasks suggest that autistic people attend significantly less to eyes/faces than TD people (Chita-tegmark, 2016), but during real-world face to face interactions Vabalas and Freeth (2016) showed that individuals who have stronger autistic traits are less likely than TD individuals to visually explore the environment (no difference in looks to people). Thus, in line with theories of atypical attention distribution in autism, we tested the prediction that compared to TD individuals, autistic people would be less likely to look at their conversation partner’s eyes (here eyes are considered as a region interest within the face, namely representing social attention). Also, previous literature has shown that people are more likely to look at their conversation partner's face when talking about their own topic of interest or a topic that is easier for them to talk about (Nadig et al., 2010). Hence, we tested the prediction that participants would exhibit a higher likelihood of fixations on their partner's face when talking about self and familiar others (easier topic to talk about, thus reduced mentalising costs) compared to an unfamiliar other. Further, this should be even more pronounced in autistic people, due to higher processing costs of mentalizing about unfamiliar topics/people.

5.2. Method

All methodological procedures were pre-registered on the Open Science Framework (OSF) website (see https://osf.io/g485j/).

5.2.1. Participants

Initially, a total of 53 participants were recruited using the Autism Research at Kent (ARK) database. Participants on the database were recruited from a community sample in the areas of Kent, Essex and London in the U.K., using a variety of recruitment strategies (e.g., newspaper adverts, contacting local groups, autism support groups and word-of-mouth). We deliberately avoided using university students to minimise differences in socioeconomic status between the groups. Three participants had to be excluded from the analysis due to technical problems (i.e. the experimenter could not obtain a successful calibration). Hence, the final sample consisted of 24 autistic and 26 TD participants, consistent with our pre-registered target sample size. These sample sizes were chosen a-priori to be comparable or even exceed the sample sizes used in previous research that has examined eye movements during real-world interactions among autistic and TD participants (e.g. Hutchins & Brien, 2016; Nadig et al., 2010; Vabalas & Freeth, 2016), and our own previous work on pragmatic language comprehension in autistic adults (e.g. Barzy, Black, Williams, & Ferguson, in press;

Black, Barzy, Williams, & Ferguson, 2019; Black, Williams, & Ferguson, 2018; Ferguson, Black, & Williams, 2019). Post-hoc calculations of power were conducted given the current sample size using the simr package in R (Green & MacLeod, 2016), and returned an estimated power of 87.9% with the significance level of α=.05 on 80% of occasions (as suggested by Cohen, 1988).

Participants in the two groups were matched on age, gender and IQ (measured by the Wechsler Abbreviated Scale of Intelligence; WASI; Wechsler, 1999; see Table 5.1. for demographic information). None of our participants had a diagnosis of dyslexia or reading comprehension impairments, and all were native speakers of English. All autistic participants had a formal diagnosis of Autistic Disorder, Asperger's Syndrome or Pervasive Developmental Disorder Not-Otherwise Specified (DSM-IV or 5; American Psychiatric Association, 2013). Module 4 of the Autism Diagnostic Observation Schedule (ADOS-2; Lord et al., 2000) assessed the current autistic characteristics of autistic participants. ADOS assessments were conducted by a trained, research reliable researcher (see Table 5.1.), and videos were double-coded to ensure reliability of scoring (inter-rater reliability was found to be excellent with intraclass correlation of .89). All participants completed the Autism-spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) as a self-report measure of autistic traits.

Table 5.1. Demographic information (means and std. errors) of participants in each group, where *** $p < 0.001$.

	Autistic (N=24)	TD (N=26)	*F-value*	*p-value*	*η2*
Sex (m:f)	17:7	18:8	-	-	-
Age (years)	33.79 (11.14)	34.77 (17.40)	0.23	.816	0.067
Verbal IQ	102.33 (11.23)	99.96 (9.31)	0.82	.419	0.229
Procedural IQ	106.75 (20.24)	103.35 (11.51)	0.74	.464	0.206
Overall IQ	104.71 (15.66)	102.00 (10.49)	0.72	.473	0.204
Total AQ	31.29 (9.02)	19.31 (8.28)	4.90	<.001 ***	1.383
ADOS2 Module4	8.00 (5.35)	-	-	-	-

5.2.2. Materials and design

In order to establish an unfamiliar other, a short scenario was written by the experimenters (in two versions, describing a male or female character, matched to the participant's gender). The scenario provided general information about the character (e.g. their occupation, where they are from, their hobbies; see Table 5.2. for the scenarios).

Nine questions, similar to those used in Vabalas and Freeth (2016), were designed to encourage conversation between the experimenter and the participant (see Appendix for the full set of questions). Participants were prompted to answer each question for themselves, for someone they know well (e.g. one of their parents or siblings), and for the unfamiliar character that was introduced in the scenario (e.g. "Tell me somewhere you/your mother/Marina would like to go over Christmas and why you think that?”). The questions were designed so that information in the scenario would provide some prompt to the unfamiliar other’s perspective, but participants would need to make further independent inferences about the character to elaborate with additional information (i.e. scenarios and questions were designed to encourage participants to mentalise about familiar and unfamiliar others). Questions were presented in the same order to all participants. Thus, the experiment employed a 3 x 2 mixed design, crossing the within-subjects variable Topic (Self/familiar other/unfamiliar other) with the between-subjects variable Group (ASD/TD).

Table 5.2. Scenarios describing a female/male 'unfamiliar' character.

Scenario describing a female character	**Scenario describing a male character**
Marina is from Rome in Italy. She is a 32-year-old chef, who loves cooking Italian food and baking cakes. She owns an Italian restaurant in London. Marina loves her family and likes to visit them in Rome regularly, especially on public holidays. She enjoys fashion and going shopping with friends. She also loves traveling in summer. For example, she really likes going to pretty little coastal towns in England where she can relax in the sun and read cookery books. She doesn't like rain at all so when the weather is wet, she tries her best to stay indoors. Marina also enjoys watching tennis and listening to classical music. She goes to see tennis matches or classical concerts in her free time. She has many Italian friends in London with whom she meets for a drink.	Jack is from Rome in Italy. He is a 32-year-old chef, who loves cooking Italian food and baking cakes. He owns an Italian restaurant in London. Jack loves his family and likes to visit them in Rome regularly, especially on public holidays. He enjoys watching football on TV with friends. He also loves traveling in summer. For example, he really likes going to rustic little coastal towns in England where he can relax in the sun and read cookery books. He doesn't like rain at all so when the weather is wet, he tries his best to stay indoors. Jack also enjoys watching tennis and listening to classical music. He goes to see tennis matches or classical concerts in his free time. He has many Italian friends in London with whom he meets for a drink.

To assess participants' Theory of Mind abilities we used the animations task (Abell, Happe, & Frith, 2000). In this task participants watched a series of four silent animation videos, in which two triangles interacted. Afterwards, participants were asked to describe the interactions between the triangles and say how they think the triangles felt at the end of each clip. To achieve the highest score, participants had to describe the triangles' behaviour in terms of epistemic mental states, such as beliefs, intentions, and deception. Participants' audio responses were recorded for later transcription.

5.2.3. Procedure

Ethical approval for conducting this experiment was granted by the School of Psychology Research Ethics Committee, at the University of Kent. SMI mobile eye-tracking glasses were used to record real-life eye movements. A front-facing camera on the glasses recorded a video of the scene (field of view: 60° horizontal, 46° vertical; resolution: 1280 x 960pixels), as seen by participants, and binocular eye movements around this scene were recorded at a sample rate of 60Hz (with 0.5° accuracy). Corrective lenses of the appropriate prescription could be attached to the eye-tracking glasses if necessary.

Participants were tested in a quiet laboratory at the School of Psychology, University of Kent. After giving consent to participate, participants were asked to read the unfamiliar other scenario, with the character matched to their gender. They were told that they would have a conversation with the experimenter about themselves, a familiar other (of their choosing, e.g. their mother), and an unfamiliar other (the character introduced in the scenario). Next, participants were fitted with the eye-tracking glasses, the experimenter ensured that they were comfortable, and participants completed a 3-point calibration and validation procedure. The experimenter sat in a chair opposite the participant, approximately one meter away.

Participants were asked to choose a family member/friend that they could answer familiar other questions for, and were reminded that they did not need to restrict their responses for unfamiliar other questions to the information provided in the scenario, but they should try to guess/expand their answers based on this information. The aim was to encourage participants to converse longer with the experimenter and to mentalise about the characters in the scenarios. Each participant responded to 27 questions in total (nine questions, in each of the three Topic conditions). Participants were encouraged to talk for approximately 30 seconds for each question. The experimenter prompted for further information when necessary, and responded naturally to participants' responses to facilitate the flow of conversation. The entire conversation task took approximately 30 minutes to complete. Finally, participants removed the eye-tracking glasses, and completed the animations task on a computer. The whole experiment took approximately 40 minutes to complete.

5.3. Results

All analysis procedures were pre-registered, and the full datasets and analysis scripts are available on the Open Science Framework web pages (see https://osf.io/g485j/).

5.3.1. Animations Task

To verify that ToM was diminished in our autistic sample, each verbal transcription was scored on a scale of 0–2 for accuracy (including reference to specific mental states), based on the criteria outlined in Abell et al. (2000). This resulted in a total score for each participant between 0 and 8 (with a higher score indicating better mentalizing abilities). Twenty percent of transcripts were scored by two independent raters. Inter-rater reliability across all clips was excellent according to Cicchetti's (1994) criteria (intraclass correlation =.85). Results showed that autistic participants were significantly impaired at describing the animations in terms of their mental states compared to TD participants (Ms = 4.17 *vs* 5.38, respectively; $t(48) = 2.04$, $p = 0.047$, d = 0.57).

5.3.2. Eye movement data processing

SMI BeGaze analysis software (3.7.59) was used to prepare fixation data for analysis. First, annotations were manually inserted into the timeline for each participant to indicate the onset and offset of each verbal response, and to code for conversation topic (self, familiar other, unfamiliar other). Next, fixations during the verbal responses were manually assigned to one of four areas of interest (AOIs): the experimenter's eyes, face, body, background (see Figure 5.1.). The background AOI was defined as any area in the scene except for experimenter. Analyses were conducted on the proportion of time spent fixating each AOI per condition and group, which was calculated separately for each participant and question (item) as: summed duration of fixations on a specific AOI / sum of all fixation durations on all AOIs.

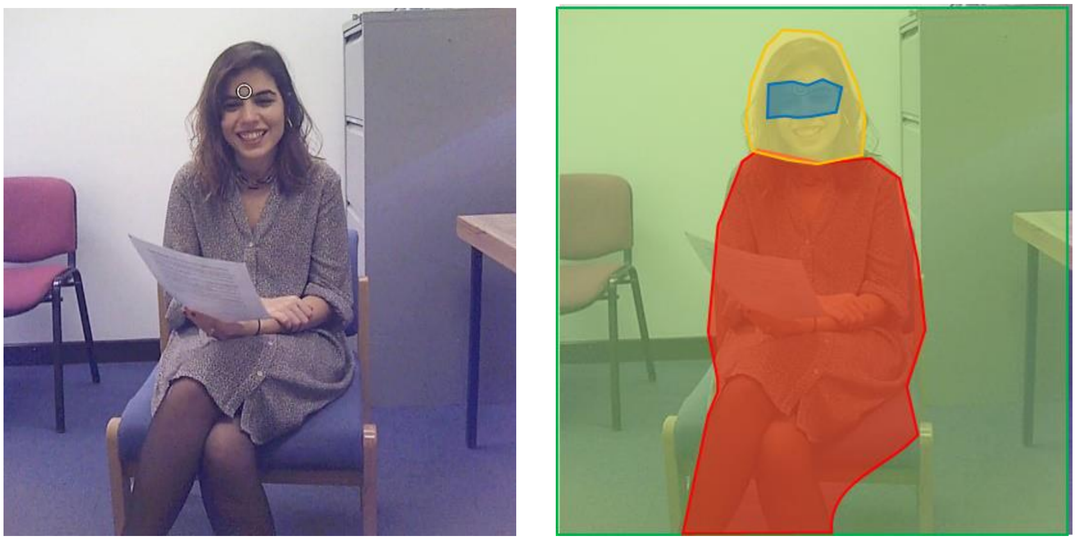

Figure 5.1. A screenshot of a typical view seen by participants during the experiment, and the corresponding AOIs for that view (eyes: blue, face: orange, body: red, background: green).

Linear mixed models and lmer in the lmer4 packages in Rstudio software were used to analyse the data (Bates, et al., 2014; Version 1.1.453, R Core Team, 2016). Four separate models were used to analyse data from each of the four AOIs (eyes, face, body and background). Each model included fixed effects of Topic and Group, and random effects of items and participants. Since the effect of Group had two levels, it was contrast coded (-.5 *vs* .5). To accommodate the three levels of Topic, deviation coded contrast schemes were used to compare each of the ‘other’ conditions to the baseline ‘self’ condition: Familiar other *vs* Self (Self (-.33), Familiar (.66), Unfamiliar (-.33)), and Unfamiliar other *vs* Self (Self (-.33), Familiar (-.33), Unfamiliar (.66)). Models also included the maximal random structure, including crossed random slopes for Group and

Topic within items, and crossed random slopes for Topic within participants. When the model did not converge the random slopes that accounted for the least variance were removed (as suggested by Barr, Levy, Scheepers & Tily, 2013). Details of the final models used to analyse data for each AOI are presented in the supplementary materials. Note that due to space constraints, only significant effects are presented in the text. Full statistical effects are presented in Table 5.3.

Table 5.3. Model Estimate, Standard Error (SE) and t/z value for each measure in each region, where *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

	Est.	*SE*	*t*-value
Eyes			
Topic: Self *vs* FamiliarOther	-0.006	0.009	-0.589
Topic: Self *vs* UnfamiliarOther	-0.041	0.009	-4.269 ***
Group	0.072	0.054	1.32
Topic: Self *vs* FamiliarOther * Group	-0.023	0.019	-1.223
Topic: Self *vs* UnfamiliarOther * Group	0.006	0.019	0.331
Face			
Topic: Self *vs* FamiliarOther	-0.016	0.009	-1.793
Topic: Self *vs* UnfamiliarOther	-0.021	0.009	-2.428 *
Group	0.134	0.052	2.557 *
Topic: Self *vs* FamiliarOther * Group	0.011	0.017	0.627
Topic: Self *vs* UnfamiliarOther * Group	0.031	0.017	1.763
Body			
Topic: Self *vs* FamiliarOther	0.004	0.008	0.472
Topic: Self *vs* UnfamiliarOther	0.005	0.008	0.587
Group	-0.014	0.040	-0.349
Topic: Self *vs* FamiliarOther * Group	0.016	0.017	0.928
Topic: Self *vs* UnfamiliarOther * Group	0.027	0.017	1.621
Background			
Topic: Self *vs* FamiliarOther	0.012	0.012	1.066
Topic: Self *vs* UnfamiliarOther	0.045	0.012	3.849 ***
Group	-0.181	0.054	-3.354 **
Topic: Self *vs* FamiliarOther * Group	0.006	0.023	0.263
Topic: Self *vs* UnfamiliarOther * Group	-0.050	0.023	-2.121 *

5.3.3. Eye movement analyses

Eyes: Analysis revealed a significant effect of Topic, with a greater proportion of fixation time spent on the experimenter's eyes when participants were talking about the self than when they were talking about an unfamiliar other (M = 0.24 *vs* 0.20). Neither the effect of Group nor the self *vs* familiar other Topic contrast was significant, and Group did not interact with Topic. Figure 5.2. shows the proportion of time spent fixating the experimenter's eyes in each condition and group.

Face: Analysis revealed a significant effect of Group, reflecting the expected reduction in social attention among autistic participants; autistic adults in the current study spent significantly less time than TD comparison adults looking at the experimenter's face (M = 0.13 *vs* 0.26). A significant effect of Topic showed that, overall, participants spent a greater proportion of time fixating on the experimenter's face when they were talking about the self than when they were talking about an unfamiliar other (M = 0.21 *vs* 0.19). Fixation patterns on the experimenter's face did not differ between self and familiar other conversation topics, and Group did not interact with either Topic contrast. Figure 5.2. shows the proportion of time spent fixating the experimenter's face in each condition and group.

Body: None of the effects reached significance on this AOI.

Background: The effect of Group was significant, replicating previous research in showing that autistic adults spent a greater proportion of time fixating the background, than the TD participants (M = 0.50 *vs* 0.33). The effect of Topic was also significant, reflecting a greater proportion of fixations on the background when participants were talking about an unfamiliar other compared to when they were talking about the self (*M* = 0.43 *vs* 0.39). No difference in fixations to the background was found between self and familiar other conversation topics.

Moreover, Group significantly modulated the effect of self *vs* unfamiliar other Topic. To examine this effect further, post-hoc tests compared fixations on the background for self *vs* unfamiliar other Topics, separately for each Group. In the autistic group, the effect of Topic was significant (*Est.* = 0.069, *SE* = 0.019, $t = 3.598$, $p < 0.001$), showing a greater proportion of fixations on the background when participants were talking about an unfamiliar other compared to when they were talking about the self (M = 0.54 *vs* 0.47). In the TD group, the effect of Topic did not reach significance (*Est.* = 0.020, *SE* = 0.013, $t = 1.480$, $p = 0.139$), thus fixation patterns around the background did not differ between self and unfamiliar other conversation topics among TD adults.

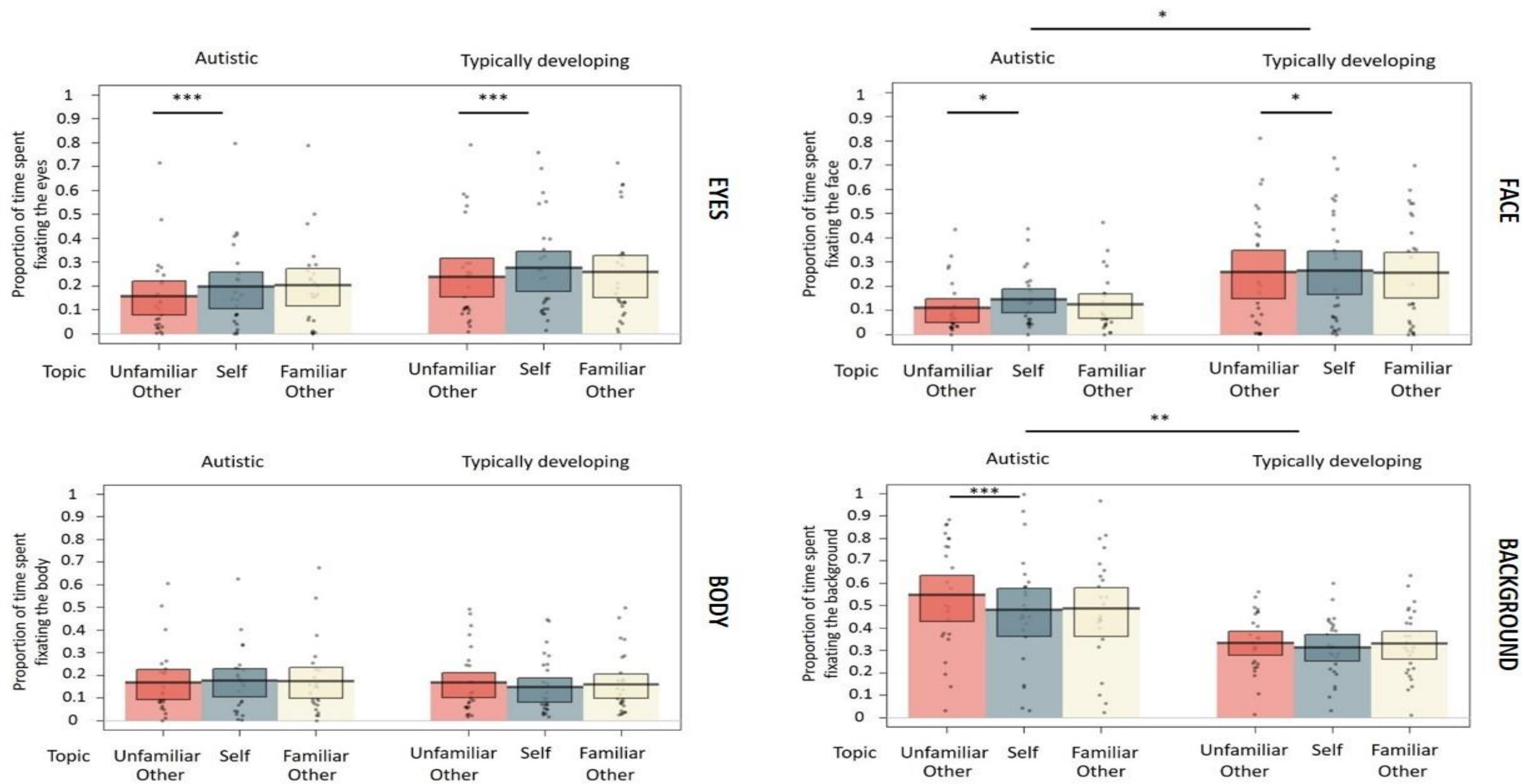

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Figure 5.2. The proportion of time spent fixating each AOI in each condition and group (top left: eyes, top right: face, bottom left: body, bottom right: background). The plots show raw data points, a horizontal line reflecting the condition mean, and a rectangle representing the Bayesian highest density interval. Asterisks indicate significant differences between conditions (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

5.4. Discussion

In a pre-registered experiment, we tested two novel objectives. First, we studied the pattern of eye movements during real-life social interactions in autistic and non-autistic individuals, a topic which has received little attention. Second, in the first study of its kind, we explored whether patterns of eye movements differ when individuals take the perspective of self *vs* others. Specifically, we were interested to see whether the pattern of gaze to social aspects of environment (i.e. the experimenter here) differs when people (autistic and non-autistic) mentalise about 'self' *vs* 'someone they know' (a familiar other) *vs* a 'stranger' (an unfamiliar other).

Regarding between-group differences in eye movements, we found that autistic participants spent significantly *less* time than TD participants looking at the face of the experimenter regardless of the topic being discussed. Conversely, autistic individuals spent significantly *more* time than TD participants looking at the background when talking with the experimenter (particularly when the conversation was about an unfamiliar other).

These findings are largely in line with findings from Freeth and Bugembe (2019), the only eye-tracking study other than ours to involve a physically-present social partner and autistic participants. Similar to the current findings, Freeth and Bugembe found that, overall, autistic individuals looked at the experimenter's face for a smaller proportion of time than did neurotypical comparison participants, at least in a condition in which the experimenter was directly looking at the participant (which is equivalent to our study, in which the experimenter always looked at the participant). However, our results contrast with those of Nadig et al. (2010), who did not observe any significant between-group differences in proportion of time spent looking at the social partner's face during online social interaction. There are several issues to consider when comparing Nadig et al.'s results to our own, however. The first is that the sample size in Nadig et al. was relatively small (N = 12 ASD and N = 11 TD participants in their study compared to N = 24 and 26 respectively in our study). As such, Nadig et al.'s study had particularly low statistical power to detect between-group differences, which could, potentially, have led to a type II error. The second issue is that Nadig et al.'s study used children, rather than adults. One possibility is that social attention follows an atypical developmental trajectory in ASD. It is conceivable that autistic children show typical patterns of eye gaze to faces, and that atypicalities only emerge later in development, perhaps as a result of increasing aversion to direct eye contact, rather than because of a core representational difficulty. This latter possibility seems unlikely, given early-emerging difficulties with several aspects of social attention (including joint attention). However, given that very little is currently known about gaze to social stimuli in real-life social interactions among autistic people, it might be beneficial for future studies to explore this issue and attempt to replicate findings among both children and adults.

One important finding in the current study was that significant between-group differences in the proportion of time spent looking at the eyes of the experimenter/social partner did not emerge. As noted in the Introduction, there is a question about the extent to which gaze to eyes is impaired/diminished in ASD. While several studies have reported reduced gaze to eyes among autistic people (Chita-Tegmark, 2016; Corden, Chilvers, & Skuse, 2008; Guillon, et al., 2014), other studies have failed to observe any such reduction (Bar-Haim, et al., 2006; Fletcher-Watson et al., 2008; Van Der Geest, Kemner, Verbaten, & Van Engeland, 2002). There is, arguably, a need for this issue to be addressed in further eye-tracking studies involving live, physically-present social partners. The presence of live social partners adds ecological validity in studies of social attention and, in this way, the current study adds weight to the notion that gaze to eyes is not diminished among autistic adults during real-world interactions.

Regarding within group patterns of performance across conditions, we found that individuals in both groups were more likely to look at the experimenter’s eyes and face when talking about themselves compared to an unfamiliar other. This is line with our prediction and shows that topic of conversation can modulate social attention in both autistic and neurotypical adults. Arguably, these patterns reflect the differential costs of processing information/mentalising about oneself *vs* an unfamiliar other. Because self-relevant information is processed more easily and efficiently than information about others, especially unfamiliar others (see Lind et al., 2019), it may be that social attention is facilitated by the reduction in cognitive load associated with processing self-relevant *vs* other-relevant information. This idea is in keeping with findings that there is an increased cognitive load associated with representing the mental states of others when those mental states differ from one’s own compared to representing others mental states that are the same as one’s own (Apperly, Back, Samson, & France, 2008; Schneider, Lam, Bayliss, & Dux, 2012). The fact, however, that attention to faces was reduced among autistic participants even in the self- condition suggests that the advantage conferred by processing self-relevant over other-relevant information is not sufficient to overcome entirely the social attention difficulties observed in autistic people.

When it came to (non-social) eye gaze toward the background, we found a particularly important interaction between group and topic. Autistic participants showed significantly increased gaze toward the background compared to TD participants across all three topics of conversation, which likely reflects the social and cognitive load of managing the interaction (Doherty-Snedon, Whittle, & Riby, 2013). However, the between-group difference in gaze to the background was reduced in the self-condition relative to the unfamiliar-other condition. This suggests that social attention was facilitated by self-reference among autistic participants, which is an important and novel finding. However, an alternative explanation for this particular finding is that autistic participants simply found it more difficult to recall details of, or construct details about, the unfamiliar other than they did to generate self-relevant information. While it is well-established autistic adults have difficulties with this kind of recall or construction process (e.g., Lind et al., 2014), we think it is unlikely that these difficulties affected patterns of eye-tracking in the current study. Notably, at the beginning of the experiment, the experimenter explicitly instructed the participant that the conversation task was not a memory test. Rather, the participant was encouraged to base his/her responses on what they think about the characters and not solely on what they read in the scenarios.

Several questions remain to be answered that are beyond the scope of this experiment. For example, it would be important to explore what the moderator cognitive mechanisms underlying this atypical visual attention are. Hutchins and Brien (2016) demonstrated that working memory abilities are correlated with number of fixations on the experimenter's eyes (higher working memory scores resulted in more looks at the experimenter's eyes). So, further work needs to be carried out to establish whether executive functions modulate visual attention during real-life social interactions. Plus, previous studies have established that there are differences when looks to the mouth and eyes are coded separately, with autistic participants being more likely to look at the mouth of the experiments compared to their eyes (Chita-Tegmark, 2016). In this study fixations on the mouth were aggregated with looks to other regions of the face, except for the eyes (as per our pre-registered analysis plan), so future research should separate these regions and explore this further.

In conclusion, this study explored the eye gaze behaviour during real-life social interactions, when autistic and non-autistic adults processed information about themselves, someone they know, or a stranger. Our results provide further evidence that social attention is atypical in ASD and that adults with this disorder show a pattern of eye gaze characterised by increased focus on non-social aspects of a scene at the expense of eye gaze toward (at least some) social aspects of the scene. Moreover, the current results add to evidence that the type of information being processed during conversation influences patterns of eye gaze/social attention. It is clear that social attention has a processing cost attached to it and this can be mitigated when the topic of conversation is relatively cognitively undemanding, i.e. relating to the self or a familiar other. This mitigation might enhance social attention in autistic people particularly. Further research into this question could be beneficial not only for our understanding of ASD, but also for our understanding of the underlying basis of social attention more generally.

Chapter 6: General Discussion

6.1. Overview

In this thesis I set out to investigate how autistic and non-autistic individuals infer and use the social context to guide language processing and interpersonal attention allocation during social interactions including simulating perspective from language, using social stereotypes about a speaker to infer meaning, tracking other peoples' emotional states and interpreting their literal/figurative meaning, and distinguishing self and others in conversation. In the first chapter of this thesis, I discussed three prominent theories of language processing, including the schema theory, the situation model theory, and the embodied view of language processing. These theories converge on the conclusion that language goes above and beyond processing the text; comprehension is embodied in action and cognition, and mental representations of text are built and constantly updated to facilitate the comprehension process. Nevertheless, I highlighted that these theories fail to take into account how the broader context in which language is presented in influences the comprehension process. Some of these contextual factors include, our body language, the audience, others' mental states, our world knowledge etc. This topic has been widely studied in TD individuals, showing that there is a tight relationship between the situational context and the linguistic input. Importantly, some of the strongest evidence for contextualised language processing comes from research that has used sensitive online measures to show that these contextual factors are immediately taken into account when we process language. Little is known about this topic in autistic individuals, despite the known difficulties that this group experiences with global coherence and social communication. Thus, this thesis set out to explore how autistic individuals build mental models of text online, specifically testing the time-course with which they combine the broader social context with the linguistic input.

Considering that this topic is under researched in autism and the existing findings provided mixed findings, we investigated these top-down processes in HFA adults. I purposefully chose to conduct my research on autistic adults, since the majority of previous research in autism has been limited to autistic children (who may experience a developmental delay in acquiring these social-cognitive or language skills), and uncertainty still exists about the cognitive mechanisms that underlie language processing in autistic adults. Moreover, I believe that researching autistic adults can provide novel insights in this area in a relatively stable population, where the differences observed are not necessarily due to developmental differences that may still exist between the groups. Furthermore, the tasks that were used in this thesis were relatively complex language tasks which made high demands on cognitive abilities, so all participants were matched on measures such as age, gender, verbal and perceptual IQ.

In this thesis, techniques such as eye-tracking (mobile and static) and ERPs were used to study the online processes of language processing. I believe that studying these online processes provides us with important insights regarding the social and cognitive differences that exist between the groups, and the different strategies that they may apply to process language. Most of the existing studies in this area are limited to lab-based studies where language is highly structured and the social context is relatively artificial. As such, I also used mobile eye tracking to study the differences in eye movements between autistic and TD individuals during real-life social interactions when they mentalise about the self *vs.* others.

The following sections of this chapter will summarise the findings from each experiment to address the three questions that were introduced in Chapter 1: 1) how does representing others' mental states and perspective influence language processing and real-life social interaction in autism, 2) whether and at which stage contextual factors, such as social stereotypes, voice of speaker and emotions etc. are integrated with linguistic input and whether the time course of these processes are comparable in autistic and typically developing (TD) individuals, and finally 3) do autistic and non-autistic people mentally simulate text and its different dimensions while processing language? I will then interpret these findings in relation to existing theories of autism research, discuss some general limitations of the studies discussed here and address how the findings can inform the direction of future research in this area.

6.2. Summary of results

6.2.1. Is representing others' physical perspective necessary for comprehending language?

Both the situation model and the embodied theories of language processing suggest that comprehension involves mental simulation of language and embodying the actions that are described within the story (Glenberg & kaschak, 2002; Zwaan, 2009; Zwaan & Radvansky, 1998). Recently there has been increased interest in whether personal *vs.* external pronouns encourage individuals to adopt distinct perspectives, and whether these simulations of perspective are necessary for comprehension (Brunyé et al., 2009; Ditman et al., 2010; Sato et al., 2013). The majority of research in this area has tested an embodied point of view, but some researchers have examined 'perspective' as a contextual factor that might enhance the experience of reading and facilitate the comprehension process (Hartung et al., 2016). Since autistic participants struggle with both integrating information from different sources and representing mental models of text, it seemed important to know whether comparable simulations of perspective are activated in adults with autism (Au-Yeung et al., 2015; Happé, 1994). However, before testing this effect in autistic individuals, I first aimed to replicate the original findings in a non-autistic sample.

In Experiments 1 and 2 I used the SPV paradigm to investigate whether personal ("I" and "you") *vs.* external ("he/she") pronouns influence the perspective that individuals adopt while they process language. Participants in both experiments were presented with action sentences, such as "I am/you are/he/she is slicing the tomato". Immediately after, participants were presented with a picture that depicted the same or a different action from either an internal (i.e. from the participant's point of view) or an external (i.e. from an observer's point of view) perspective. Participants had to respond whether the action in the sentence matched the event that was presented in the picture. Based on Brunyé et al.'s findings (2009), it was hypothesised that participants would be more accurate and faster responding to an internal *vs.* external picture when a personal pronoun was used, and vice versa for an external pronoun. The findings from Experiment 1 revealed that participants were more accurate to respond to pictures depicting an external perspective, regardless of the pronoun used in the preceding sentence. The reaction data also demonstrated a facilitation effect for external perspective pictures when an external pronoun, such as "she" and "he", was used.

Hence, in this experiment there was no evidence of a personalisation effect when personal pronouns were used, thus failing to find the same effect as Brunyé et al. (2009).

In Experiment 2, we replaced the materials that we developed in our lab for Experiment 1, with those used in Sato et al.'s study (2013) to ensure that the lack of replication was not due to differences in the materials. The experiment was updated to carefully replicate Sato's study, using 3-sentence scenarios that clearly established the perspective to adopt before the picture was displayed (i.e. pronouns were repeated three times before the picture appeared). The first two sentences were used as context sentences giving a short description about the character in the story. The last sentence in each scenario was similar to the sentences used in Experiment 1, but this time only the pronouns "you" and "he/she" were included (as in Sato's study). Participants were faster responding to external pictures when the pronoun "you" was used, which is opposite to Sato et al.'s findings (2013). All the other main and interaction effects for accuracy and reaction time data were non-significant. Thus, despite matching the number of participants and using identical materials to those in Sato et al. (2013), we once again failed to replicate the perspective simulations effects reported in Sato et al. (2013) and Brunyé et al. (2009).

In Experiment 3 used a different paradigm to test the effect of perspective on memory. Based on embodiment accounts, Ditman et al. (2010) used a memory task to test whether individuals would internalise the actions that were presented through personal pronouns. They hypothesised that if this is true, then based on the enactment effect, individuals should be better at remembering actions that were presented through personal pronouns (Engelkamp, 1998). Conducting a study similar to Ditman et al.'s study (2010), our participants were presented with 3-sentence scenarios (as in Sato et al.'s study), using "I", "you" and "he/she" pronouns. Participants' memory for actions and descriptions was tested following delays of 10 minutes and 3 days. The d-prime (signal detection) analysis revealed that participants were better at remembering the action words for both personal pronouns "you" and "I" relative to the pronouns "he/she" after 3 days, but but did not differ after a 10-minute delay. The reaction time data did not reveal any significant differences in terms of the pronoun use. Hence, the results of this experiment were partially in line with the results from Ditman et al. (2010), who observed a greater sensitivity to the action words when pronouns "you" was used relative to both pronouns "I" and "he/she".

In conclusion, Experiments 1, 2 and 3 provided little evidence that linguistic cues, such as pronouns, modulate the perspective that individuals adopt while processing language. Using both SPV and memory paradigms gives us confidence that the lack of generalisability is not due to the type of the tasks that were used. In fact, in a recent study Brunyé, et al. (2016) argue that comprehension is intact, even when individuals do not represent the perspective that is described in text. Brunyé et al.'s findings (2016) showed that while processing a discourse, the level of empathetic engagement with the characters in the story can predict whether individuals will be likely to adopt the agent's perspective. Analysing their previous findings, they found that only 39% of participants in their sample successfully represented the perspective that was primed by using external and internal pronouns, showing that this effect is small in nature. Thus, they suggest that future research should take into account individuals' cognitive processing styles, since it seems that people process text in embodied (grounded in perception and action) and disembodied (amodal approach) manners. Hartung et al. (2017), who also found null results for personal pronouns, suggest that individual differences such as, mental imagery and preferences in perspective-taking determine whether and which perspective individuals adopt when processing language. The finding that personalised language did not have a robust influence on participants' mental simulation of described events is consistent with other recent work that has failed to replicate findings on embodied language processing (e.g. sentence-action compatibility effects, Papesh, 2015; colour simulations, Zwaan & Pecher, 2012).

Hence, based on our findings and previous literature, future research should continue exploring the range of individual differences that influence this process. Also, it would be interesting to see whether the results differ when adopting the perspective of characters facilitates or is necessary for comprehension. Considering, the null findings in these experiments, I did not proceed to conduct the same experiment in autistic individuals and instead switched to testing broader questions regarding the influence of social context on language processing in autism using sensitive online measures.

6.2.2. While processing language online, do autistic adults integrate the social stereotypes with the linguistic input?

Based on the 'social Coordinated Interplay Account' (sCIA), suggested by Münster and Knoeferle (2018), we take into account our knowledge of speaker while processing language in real-time, including their mood, age, gender etc. Van Berkum et al. (2008) observed a larger N400 effect when there was an inconsistency between the speaker's voice and the message they were trying to send, suggesting that processing language involves immediate integration of social context with the input from speaker. However, little is known about the same processes in autistic individuals. While theories such as WCC, suggest impairments in context integration in autism, there is evidence that this is more dependent on the type of context and the situation they are in rather than an absence of it (Ben-Yosef, Anaki, & Golan, 2017). Hence, in Chapter 3 I aimed to explore the integration processes of social stereotypes with language in autism. Furthermore, I explored for the first time whether autistic and non-autistic individuals also *anticipate* the language based on these stereotypes. It was hypothesised that TD individuals would use the speakers' voice and it characteristic, such as age, gender and accent, to anticipate and integrate the message they were trying to send, however, due to social impairments and a local processing bias in autism, it was expected that this effect would be absent or reduced in size in the autistic individuals.

In Experiment 4 I used a visual world paradigm to explore the time-course of anticipating unfolding language, based on speaker and message. Participants listened to sentences, in which the voice of the speaker was either consistent or inconsistent with the message (e.g. "when we go shopping, I usually look for my favourite wine" in a child or an adult's voice). Visual scenes that depicted these consistent and inconsistent objects alongside distractor objects were concurrently presented to participants while their eye movements were recorded. Participants in both groups were slower to select the mentioned picture when it was inconsistent with the speaker's voice (and therefore the expected message). Eye-tracking revealed a visual bias towards the target object that was consistent with the speaker's voice well before this word was disambiguated in the audio, showing that autistic adults rapidly used the speaker's voice to anticipate the intended meaning. However, this target bias emerged earlier in the TD group compared to the autistic group (2240ms before the disambiguation in the TD group *vs.* 1800ms in the autistic group). Furthermore, the autistic group showed some interference from the competitor picture in the anticipation period, and were faster to switch away from a consistent target picture during the integration period. These group differences show that autistic adults were either less bound to the social stereotypes or had weaker speaker meaning inferences, suggesting that perhaps they struggled to ignore prediction errors (i.e. attributing more weight to the bottom up errors), which supports the predictive coding theory of autism (Van Boxtel & Lu, 2013). These subtle differences in the time-course of anticipation (~440ms delay in the autistic group) and influence of bottom-up competitors (greater interference in the autistic group) may not lead to a noticeable disruption to comprehension under tightly-controlled lab-based conditions or when short language extracts are tested, but it is likely that these difficulties would be magnified in fast-moving interactive social situations (as in real life), and impairments to the quality of understanding become cumulative.

Experiment 5 replicated and extended van Berkum et al.'s study (2008) to examine integration of social context on interpreting language meaning. Participants listened to sentences of the same type as in Experiment 4 (e.g. "I tried to refresh my lipstick in front of the mirror" in a man or a woman's voice), while ERPs were recorded. A third sentence condition was also included, in which participants heard sentences that were semantically anomalous, as the baseline measure of N400 effects (e.g. "I tried to refresh my seashell in front of the mirror"). Results demonstrated that participants took into account the speaker's voice as early as 200ms after hearing the inconsistent word; group did not influence this effect. This effect was comparable to the semantic anomaly N400 effect, showing that pragmatic information is taken into account as quickly as semantic information to facilitate the comprehension process. All participants were also tested on the RMIV task, in which they had to explicitly recognise a character's emotional state from their voice (Golan et al., 2007). As expected, autistic individuals were significantly less accurate to complete the task compared to the TD individuals.

In conclusion, Experiments 4 and 5 provided further evidence for the sCIA and one-step model of language processing, showing immediate integration of social context and language input (Clark, 1996; Münster & Knoeferle, 2018; Perry, 1997), including in the autistic group. For the first time, it was also shown that individual used the social stereotypes to *anticipate* the speaker's intended meaning. The finding that the autistic group immediately took into account the social context by inferring the characteristics of the speaker from the voice and using it to facilitate the comprehension goes against the WCC theory of autism. The subtle group differences observed in terms of the time-course of anticipation, and also their experience of interference from semantically-appropriate (but not speaker-appropriate) competitors, could be used an evidence that autistic individuals had difficulties ignoring the bottom up-errors, supporting the predictive coding theory of autism. Considering that autistic individuals had intact abilities inferring the social stereotypes from the voice of speaker but struggled with extracting the emotions from the same information, indicates that they may struggle with inferring and integrating the higher cognitive functions with higher demands, such as emotions and mental states.

6.2.3. How do autistic individuals infer and keep track of characters' emotional states online in a story?

In Chapter 4 I investigated the emotional processes of using figurative language when readers were required to shift perspectives between the characters of the story. The aim was to see how autistic and non-autistic individuals infer and keep track of the emotional states of characters in stories when the task makes greater demands on cognitive abilities (i.e. load on memory and cognitive flexibility). Previous research has shown while building mental models of text online, TD individuals represent the emotional states of the characters in the story and update them as they proceed through the text (Filik et al., 2017). While studying the online emotional processes of ironic criticism, Filik found a two-stage process with participants initially finding ironic comments harsher than literal criticism, but eventually considering it as more humorous or amusing. Filik also found that based on the perspective described in the text (protagonist *vs.* victim), individuals represented different emotional processes. The studies on irony processing in autism offer mixed results, whilst some suggest that autistic individuals have impairments representing the mental states of others and understanding irony, others believe that processing irony is intact in autism and autistic individuals only struggle with processing the emotional language and building coherent mental models of discourse (Au-Yeung et al., 2015; Baron-Cohen et al., 1995; Happé, 1993; Lartseva, Dijkstra, & Buitelaar, 2015). Hence, this chapter aimed to investigate the online emotional processes of using irony in autistic individuals for the first time.

Furthermore, I also investigated whether these emotional processes differ when individuals take the perspective of the victim *vs.* the protagonist.

Similar to Filik e al. (2017), participants were presented with scenarios in which a victim was criticised by a protagonist, through an ironic or literal comment (e.g. "that was fantastic/horrendous parking"). At the end of each scenario, participants read a target sentence in which either the protagonist had intended to hurt/amuse the victim by making the comment, or the victim found the comment as amusing/hurtful. Participants' eye movements were recorded as they read the scenarios to see how they integrate emotional responses from the victim or the protagonist's perspective. Results from the TD participants showed a similar pattern of results to the findings by Filik et al. (2017), showing a two-stage process while processing the ironic language online. TD participants found it easier to integrate a hurt response for the protagonist at the critical region (i.e. the emotional word), then in the post-critical region (i.e. the word which proceeded the emotional word) found it easier to integrate an amused response when taking the victim's perspective. These results support the tinge hypothesis, showing that using ironic language dilutes a negative message (Dews & Winner, 1995; Dews et al., 1995).

Importantly, this effect was absent in autistic individuals, showing that they did not differentiate between the emotional responses of ironic *vs.* literal language. Since, completing this task relies heavily on extracting the emotions/mental states of the characters in the story, the results are in line with a ToM impairment of autism (Baron-Cohen et al., 1995). Furthermore, participants in both groups were tested on the animations task, in which they had to infer mental states of two triangles in different videos (Abell et al., 2000). Compared to the TD participants, autistic participants were less accurate at representing the mental states of the triangles. An alternative explanation for the reduced sensitivity to emotional states in the autistic group could be that they had limited understanding of functions of using the ironic language (i.e. bringing amusement in others, diluting the negative message etc.; Pexman, 2003; Pexman & Glenwright, 2007). Considering that previous research has indicated intact processing of ironic language in autism, our study suggests that impairments are more related to the socio-emotional processes of using irony rather than processing its linguistic structure (Au-Yeung et al., 2015).

Nevertheless, this experiment revealed some evidence that autistic participants successfully tracked the two characters' perspectives and were able to infer their basic emotional responses (despite their difficulties *switching* perspectives when the literal/ironic narrative required it). Regressions out from the critical word showed that autistic readers were immediately sensitive to the victim's expected emotions following the criticism (i.e. they found it more difficult to integrate an amused emotion). This finding is consistent with other research I conducted alongside the work in this thesis (Black, Barzy, Williams, & Ferguson, 2019). We conducted a pre-registered experiment that examined how autistic and non-autistic adults process counterfactual emotions in real-time, based on research showing that autistic adults experience broad difficulties identifying and interpreting emotions in the self and others (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Uljarevic & Hamilton, 2013), and that the developmental trajectory of counterfactual thinking may be disrupted in autistic people (Grant, Riggs, & Boucher, 2004). Participants (N = 24 TD and 24 autistic) were eye-tracked as they read narratives in which a character made an explicit decision then subsequently experienced either a mildly negative or positive outcome. The final sentence in each story included an explicit remark about the character's mood that was either consistent or inconsistent with the character's expected feelings of regret or relief (e.g. "… she feels happy/annoyed about her decision."). Results showed that autistic adults were unimpaired in processing emotions based on counterfactual reasoning, and in fact showed *earlier* sensitivity to inconsistencies within relief contexts compared to TD participants. These findings highlight a previously unknown strength in empathy and emotion processing in autistic adults, which may have been masked in previous research that has typically relied on explicit, response-based measures to record emotional inferences, which are likely to be susceptible to demand characteristics and response biases. This study therefore complements the work presented in this thesis by highlighting the value of employing implicit measures that provide insights on peoples' immediate responses to emotional content without disrupting ongoing processing.

This undiminished emotional processing at first appears at odds with previous studies that have shown atypical processing of emotions in autistic people (e.g. Begeer et al., 2014; Zalla et al., 2014). However, it is likely that this discrepancy reflects the different paradigms and measures employed, particularly whether inferences were observed on explicit or implicit measures. For example, Begeer et al. (2014) measured emotional processing by directly asking children to identify and explain a character's feelings. Autistic Children were poorer at than TD children at explaining relief and contentment emotions, but did not differ when explaining regret and disappointment. Similarly, Zalla et al. (2014) directly probed participants' own emotions (regret, disappointment, joy and relief) during a gambling task, and found that autistic adults reported experiencing less regret than matched TD controls, and were less able to distinguish feelings of regret and disappointment. Crucially, these impairments were observed when explicit, response-based, measures were used to record emotional inferences, which are likely to be susceptible to demand characteristics and response biases (e.g. compensatory strategies, Livingston & Happé, 2017). In contrast, the task in Experiment 6 measured eye movements in a relatively natural reading context, which allowed us to tap immediate responses to the emotional content without disrupting ongoing processing, and therefore reduced the influence of response biases (see also Howard, Liversedge, & Benson, 2017a, b, c). In line with this explicit/implicit distinction, it is interesting to note that although autistic adults were impaired at explicitly reporting their own emotions in Zalla et al. (2014)'s study, they showed implicit evidence for intact counterfactual thinking as they modified their choice behaviour in the gambling task to avoid negative feelings (i.e. anticipating regret). These findings suggest that some of the previously observed difficulty with complex emotions may be tied specifically to difficulties with the explicit expression of emotions (i.e. defining or describing emotions when directly questioned), rather than any difficulty experiencing them implicitly at a neurocognitive level. Moreover, our findings suggest that basic ability in emotional processing improves with age (as general intellectual skills improve), though difficulties persist when the cognitive demands are increased (i.e. when readers are required to infer emotions for multiple characters and switch perspectives online). Thus, the impaired emotional processing seen among children in some of the early studies (e.g. Au-Yeung et al., 2015; Baron-Cohen et al., 1995; Happé, 1993; Lartseva et al., 2015) may simply reflect a protracted period of development, whereby autistic adults reach a relatively high level of ability in emotional thinking, just later than TD individuals.

More generally, the autistic group had longer reading times and made more regressions compared to the TD group, which mirrors findings from previous studies that have used eye-tracking to examine reading comprehension in autism, and suggests that autistic people experience general processing difficulties reading complex language and building mental models of text online (Au-Yeung et al., 2015; Black et al., 2018; 2019; Ferguson et al., 2019; Howard et al., 2017a,b,c; Sansosti, Was, Rawson, & Remaklus, 2013). This is also in line with the disordered complex information processing theory, which suggests that autistic individuals show greater difficulties processing complex information. Here participants had to represent and integrate information from several different resources, including the characters' emotional states, switching between perspectives, and processing figurative language (Minshew & Goldstein, 1998). Hence, it is not surprising that they faced more processing difficulties compared to the non-autistic group.

6.2.4. How does mentalising about the self vs. others influence the patterns of eye movements during real-life social interaction in autistic people?

The final empirical chapter of this thesis was devoted to investigating language processing and social interaction among adults with autism in real-life social interactions, since most research in the area has been conducted under lab-based conditions. Although autistic individuals struggle with unpredictable situations/social stimuli, so far little research has investigated communication during real-life social interactions in autism (Nadig et al., 2010). In Chapter 5 I used mobile eye-tracking technology to examine whether the patterns of eye movements differ between autistic and non-autistic individuals when they interact with a conversation partner. Considering that Chapter 4 revealed that autistic adults struggle with representing the mental state of others, this experiment also sought to explore whether talking about the self *vs.* a familiar other (a familiar and easy topic) *vs.* an unfamiliar other (unfamiliar and requires mentalising abilities) influence this process. Research in this area is mixed with some suggesting reduced gaze to the eyes of others in autistic individuals (i.e. atypical social attention), whilst others show comparable patterns of eye movements towards the eyes and faces between TD and autistic individuals (Bar-Haim et al., 2006; Chita-Tegmark, 2016; Corden et al., 2008; Fletcher-Watson et al., 2008; Guillon et al., 2014; Van Der Geest et al. 2002). These inconsistent findings could be due to the different paradigms that have been used in the area and since most of this research are lab-based studies it is hard to draw conclusions into real-life situations. Based on the theory of atypical social attention, it was expected that TD individuals would be more likely to look at their conversation partner's eyes, compared to autistic individuals. Also, since mentalising abilities are more cognitively demanding, it was expected that all participants would be more likely to fixate on their partner's face when talking about the self and a familiar other, compared to an unfamiliar other (Nadig et al., 2010). Since autistic individuals exhibit ToM impairments, it was expected that this pattern would be even more pronounced in this group.

In this study participants read scenarios that introduced the unfamiliar other. Next, they engaged in a short interview-style conversation with the experimenter. The experimenter's questions either related to the self, someone they know well (e.g. their mother), or a stranger (the character in the scenario; e.g." Tell me who is your/your mother's/Marina's favourite celebrity and why?"). SMI mobile eye-tracking glasses recorded their eye movements. We recorded the proportion of time spent fixating on the experimenter's eyes, face, body, and the background (i.e. any area in the scene except for experimenter's eyes, face, and body). Participants in both groups were more likely to look at the experimenter's eyes and face (and less likely to look at the background) when talking about the self compared to an unfamiliar other, supporting previous literature showing tasks that are cognitively more demanding result in more gaze aversion (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, 2005). Social attention did not differ between self and familiar other contexts- reflecting greater shared knowledge for familiar/similar others. These findings suggest that difficulty of the topic of conversation directly influenced the way that interlocutors allocate visual attention.

Furthermore, supporting the social motivation theory of autism, autistic individuals looked less at their partner's face and more at the background compared to TD individuals (Chevallier, et al., 2012). This has been associated with both biological (e.g. abnormal oxytocin regulation in autism) and developmental (e.g. lack of motivation to engage with social stimuli over years) differences (Chevallier, et al., 2012). More importantly, autistic participants looked at the background much more when speaking about an unfamiliar other compared to the self. This perhaps indicates that autistic participants found mentalising about an unfamiliar other much harder than the TD adults. As well as supporting the ToM hypothesis, the findings also support the disordered complex information processing theory, suggesting more gaze aversion in autism when they had to switch between perspectives (i.e. talking about self *vs.* a familiar other *vs.* an unfamiliar other that) which loads cognitively resources (Baron-Cohen et al., 1995; Black, et al., 1979; Doherty-Sneddon et al., 2002; Minshew & Goldstein, 1998).

6.3. Interpretation of findings in relation to cognitive theories of language processing and social communication

In the first chapter of this thesis I introduced the embodied view and the situation model theory of language processing (Glenberg & Kaschak, 2002; Zwaan & Radvansky, 1998). Over the last couple of decades, numerous findings have demonstrated the validity of this mental-simulation view among healthy language users. However, the findings of the first three experiments (Chapter 2) suggest that the visual perspective presented in language is not necessarily simulated during comprehension. Although we observed some evidence that individuals activated an external or internal simulation of events according to the pronouns that were presented in language, the presence and direction of these effects were not consistent across all of our experiments. I discussed that Brunyé et al. (2016, 2013) reached the same conclusion, showing that individual differences in processing style massively influences this process. Also, Zwaan and Pecher (2012), using SPV paradigm, tried to replicate the mental simulation effect using several object entities (e.g. shape, colour, etc.). Whilst they were able to replicate the shape effect in several experiments, the colour effect was only replicated when the colour of the stimulus was necessary for comprehending the sentence (e.g. “stronger simulation effect was observed when a traffic light was used as a stimulus rather than a leaf”). Hence, the findings of this thesis fit with the findings of Brunyé et al. (2016, 2013) and Zwaan and Pecher (2012), showing that mental simulation in language is highly dependent on the entity that is being manipulated and also more importantly how relevant it is to the comprehension process. In short, mental simulation does not seem to be a necessary part of language comprehension.

In regards with theories of language processing in context, our results support theories, such as the one-step model of language processing and the social Coordinated Interplay Account (sCIA), showing that world knowledge, characteristics of the listener and speaker, and the non-linguistic context are taken into account immediately when we process language (Au-Yeung et al., 2018; Münster, & Knoeferle, 2018). In Experiments 4, 5, and 6, we observed that during both auditory and written language comprehension participants were able to infer the characteristics of the speakers from their voice and also take into account the emotional states of characters in a story while reading. In this way, these results contribute to ongoing debates about the factors that influence competition between linguistic input and contextual information (including a person’s general world knowledge or self-perspective). Memory-based views of text processing suggest that context is immediately available during comprehension, meaning that it has the potential to influence the earliest moments of language understanding (e.g. Albrecht & O’Brien, 1993). Our results are therefore consistent with the view that context (even one based on someone else’s perspective) can dominate processing over lexical input to alter the way that we interpret and use our own world knowledge/perspective for language understanding. The results therefore contrast with findings of Lattner and Friederici (2003), who suggested that the non-linguistic context or pragmatics is only processed at a second stage (i.e. after processing the sentence's message). The results suggest that language processing goes above and beyond processing the linguistic structures but in fact it is interpreted online within the context it is presented.

Finally, supporting the cognitive load hypothesis, it was observed that participants averted their gaze from experimenter's face more frequently when they talking about a topic that was more difficult in nature (i.e. a stranger compared to themselves; Glenberg, Schroeder, & Robertson, 1998). This suggests that language and visual communication processes are influenced when we process information that is cognitively demanding. Perhaps, in these situations individuals avoid processing the facial expressions, eye gaze and lip movements of the social partner to reduce the cognitive costs of the ongoing task (Doherty-Sneddon, & Phelps, 2005). However, as mentioned before there is very little research on this topic in real-life settings, hence future research should try to replicate these findings in different social settings.

6.4. Interpretation of findings in relation to cognitive theories of autism

In Chapter 1, I introduced four cognitive theories of autism, including the theory of mind impairment (ToM) hypothesis, the WCC theory, the disordered complex information processing theory, and the predictive coding theory. These theories agree that social impairments in autism originate from difficulties integrating information from different modalities and representing others' mental states (e.g. combining the language with higher cognitive functions, such as emotions, perspective etc.), however, they make distinct predictions about the mechanisms that underlie these integration difficulties in autism.

The ToM hypothesis suggests that socio-communication difficulties in autism are associated with impairments in representing the mental states of others, including their beliefs, desires, intentions etc. (Baron-Cohen et al., 1995). Throughout this thesis we found evidence to support this ToM impairment in autism; our autistic sample was significantly more impaired in completing the animations task (i.e. representing the mental states of the triangles) and RMIV task (i.e. inferring the emotional states from the voice of speaker). Furthermore, we found differences in the patterns of eye movements, both in terms of their allocation of attention social/non-social information in the environment (i.e. reduced looks to their partner's face and increased looks to background in Experiment 7), and when they had to mentalise about an unfamiliar other (Experiments 6 and 7). For example, autistic adults did not differentiate between the emotional responses of the victim/protagonist following literal and ironic criticism, and showed greater gaze aversion when they had to talk about an unfamiliar other (*vs*. self). However, based on the results, it is still hard to make specific predictions to what extent the ToM impairments influence online language processing. For example, in these tasks, as well as ToM abilities, participants had to use their world-knowledge (i.e. conceptual knowledge of irony use) or other cognitive processes, such as memory, to complete the task. Hence, it seems that the ToM hypothesis is not adequate to explain the overall group differences that were observed in this thesis. Moreover, the results here demonstrate some intact abilities to infer and use social context to guide meaning among autistic adults (e.g. Experiment 4, 5, and 6), despite this impaired ToM ability. As such, impaired ToM in autism, while clearly present, cannot explain variance in social language comprehension in this group.

In regards to the WCC theory, our results contrast with the predictions of this theory, suggesting that autistic adults are not context blind. The WCC theory suggests that non-autistic individuals process information in a global manner, incorporating cues from the wider context to get the gist of something, whilst autistic people focus more on details and miss the bigger picture (Frith & Happé, 1994). In Experiments 4 and 5, we observed that both groups inferred the characteristics of the speakers using the voice and used this in real-time to make predictions about the forthcoming language. Although there were subtle differences in the time course with which they did this, both groups clearly predicted the speaker-appropriate meaning and were sensitive to context inconsistencies (i.e. the speaker’s voice). In addition, we failed to replicate the local/global semantic effects reported by Booth and Happé (2010), in which they observed that autistic participants, compared to the TD ones, were more likely to complete sentences using a local-fit word than a global-fit word. Our linguistic central coherence task did not find any differences between the groups in terms of local vs. global preferences to complete the sentences.

The findings of this thesis are more consistent with the disordered complex information processing theory, proposed by Minshew et al. (1995). They suggest that autistic individuals struggle with completing tasks that involve processing information from multiple modalities, since this is associated with higher cognitive load. In Experiment 6, autistic adults were able to infer the basic emotional responses for story characters, but were impaired at *switching* perspectives when they had to keep track of the two characters' emotions and process the meaning of figurative language. Furthermore, they had longer reading times overall, perhaps finding it harder to process information in this task since it requires processing a large amount of information and complex linguistic structures (i.e. interpretive language). This is also in line with what Minshew et al.'s findings (1995), suggesting that autistic individuals struggle with processing interpretive and referential language, where the level of complexity increases. The findings from Experiment 7 provide further support for Minshew's theory by showing that allocation of social attention in autism is modulated by the level of difficulty of the topic of conversation. Autistic individuals showed more gaze aversion (i.e. looking at the background), when talking about an unfamiliar person (*vs.* self). This is consistent with previous literature in the area, where overall processing difficulties have been recorded while reading narratives in autism (Au-Yeung et al., 2015; Black et al., 2018; 2019; Ferguson et al., 2019; Howard et al., 2017a, b, c; Sansosti, et al., 2013).

Finally, we have found some evidence in favour of the predictive coding theory. This theory states that due to meta-cognitive impairments, autistic individuals are more impaired at ignoring bottom-up errors and consequently find it more difficult to make predictions, especially in cognitively demanding situations (Van Boxtel & Lu, 2013). In Experiment 4, despite being able to use the social context to predict language, we found that our autistic participants found it harder to ignore the information that was semantically related to the context of the sentence but did not fit in within its social context (i.e. weaker top-down processes). Autistic participants also showed weaker speaker-meaning expectations (i.e. they were slower at fixating the target picture and faster switching away from it), suggesting a stronger bottom-up processing style. Additionally, in Experiment 6 we found that autistic adults did not differentiate between emotional responses of using ironic *vs.* literal language, which could be used as evidence for the predictive coding theory of autism as our autistic participants were more impaired in making predictions about the emotional states of the characters in the story. Finally, in Experiment 7 we found that autistic individuals were significantly less likely to look at their conversation partner's face compared to TD individuals. This atypical social attention is therefore likely to impact the cues that autistic individuals use to generate and verify predictions (faces are known to convey a wealth of social information to aid communication), which in turn could lead to problems contextualising sensory input, ignoring prediction errors and applying the appropriate priors.

6.5. Limitations and future directions

In this thesis, different online and offline measures were used in both real-life and lab-based settings to provide new insights into the area of context and language processing in autism. Limitations and recommendations for future research that are specific to each study were discussed in the relevant chapter discussions, so here I will discuss some of the more general limitations of this thesis and challenges of conducting this kind of research.

First, all the autistic participants tested in this thesis were HFA adults, including people with Autistic Disorder and Asperger's Syndrome, who have normal or above average IQ (IQ>70). Some individuals with Autistic Disorder have deficits or a delay in language development, however we were careful to match our participants on verbal reasoning abilities since many of the tasks were very long (e.g. the ERP task in Experiment 5 lasted ~1.5 hours in total), involved complicated linguistic structures, and involved measures that some lower-functioning autistic individuals might not tolerate (e.g. skin abrasion and cap for EEG, wearing eye-tracking glasses). As such, our autistic groups were relatively small in size and did not include a wide range of functioning or language skill, so it was not possible to further explore variance among the autistic participants by running separate analyses within subgroups (as in Norbury, Gemmell, & Paul, 2014). Hence, the effects that were observed here are more generalisable to people with Asperger's Syndrome and the high-functioning range of people with Autistic Disorder. Future research should aim to recruit autistic individuals with more diverse social/cognitive abilities or at least with more variance in ASD traits, to systematically explore the cognitive and social skills that predict a person's experience of pragmatic and social difficulties.

Similarly, the work in this thesis focused on adults with autism, though the majority of existing research on autism has been conducted in children. It is possible then that the high performance reached among the adults here reflects a shifted developmental trajectory of social language comprehension in autism, meaning that they reached similar ability to TD adults, just later in development. Alternatively, it is possible that the adults tested here had simply developed 'compensation' strategies that facilitated performance on many of the tasks; the behavioural presentation appears improved, despite persisting deficits at cognitive and neurobiological levels (e.g. Livingston, & Happé, 2017; Livingston, Shah, & Happé, 2019). Using online measures, this thesis has established that autistic adults can integrate the context in real-time, but it would be interesting to see whether autistic children are also able to make these inferences online or whether this improves as they get older. Further research is required to investigate the developmental trajectory of these social language abilities (e.g. in autistic and non-autistic children), ideally testing a continuous age-range through childhood, adolescence and young adulthood to establish when development peaks in different groups, and what cognitive/social factors predict this peak. This is an important topic to investigate, since the existing literature in the area is mixed in this area (Lopez, & Leekam, 2003; Norbury, 2005; Saldaña, & Frith, 2007; Sansosti, Was, Rawson, & Remaklus, 2013).

Another issue that was not directly addressed in this thesis is how individual differences in cognitive abilities, such as executive functions (EF), may have influenced the context integration and ToM abilities in our autistic sample. Numerous studies have demonstrated that autistic individuals are impaired at EF skills and since these abilities, specifically response inhibition and working memory, are strong predictors of social abilities, such as ToM and pragmatics, measuring them may have helped us to understand the cognitive mechanisms underlying these integration processes and whether they differ between autistic and non-autistic autistic individuals (Hill, 2004; Martin, & McDonald, 2003; Pellicano, 2010). For example, measuring working memory abilities may have helped us to understand why under high cognitive load autistic individuals are more likely to avert their gaze from their partner's face (Experiment 7) or fail to integrate the context (Experiment 6), and measuring inhibitory control may explain the autistic participants' difficulty supressing interference from the semantically related competitor (Experiment 4). Hence, future research should include measures of individual differences in EF skills to further our understanding of how these skills interact with social inferencing that influence language processing.

Finally, ensuring an adequate sample size, and therefore statistical power, is an important issue in all psychology research, but especially so in research that involves clinical populations where recruitment is challenging. Conducting research with autistic populations is challenging because autism affects only 1% of the population and over half of autistic individuals have an intellectual impairment that would prevent them from taking part in the kind of study that we conducted. In addition, recruitment of large samples would be problematic due to the complex methods we used (as noted above), and the need to recruit and test an equal number of IQ-matched controls. In our experiments we tried to minimise these effects and improve rigour by calculating power and pre-registering each experiment a-priori (including sample sizes, methodologies and analyses). These steps were particularly important following the failed replication attempts reported in Chapter 2, and meant that the subsequent work was conducted in a transparent way. Also, we chose to use the linear and generalized linear mixed models to analyse the data, since as well as controlling for random variance across both participants and items, these models also take into account the individual data points rather than aggregating them across participants or items (Barr et al., 2013). In sum, it is important for future research to continue open practice in research, since this has benefits for clinical research especially given smaller number of participants available, and greater variability in samples available/definitions for exclusions.

6.6. Conclusions

In conclusion, I used several different psycholinguistic measures in this thesis to establish the role of non-linguistic context in language processing in autism. I used online measures (e.g. ERPs, mobile and static eye-tracking) that are sensitive to the time-course with which inferences and meaning are activated, which makes important contributions to the literature where this topic has received little attention. All experiments that included an autistic sample were pre-registered to reduce the publication and inference bias. Overall, and in contrast to predictions based on the WCC theory, the results demonstrated that context sensitivity as a general concept is intact in autistic adults. In fact, autistic individuals were able to take the social context into account in real-time to facilitate language comprehension. However, the findings also demonstrated that as the level of task complexity and cognitive load increased autistic individuals showed subtle differences in the time-course with which they integrated context with language. For example, autistic participants struggled with inferring the emotions/mentalising or maintaining eye-contact with a conversation partner, when they were required to switch between perspectives and process complex verbal stimuli.

Taken together, the results reported in this thesis support the complex information processing theory and show that ToM abilities are not the only source of socio-communication impairments in autism. In addition, it was observed that autistic individuals experienced general processing difficulties when processing complicated linguistic structures, which could suggest that they find it harder to ignore the bottom-up errors and hence they process the text in a hyper-lexical manner, supporting the predictive coding theory of autism. However, so far too little attention has been paid to how these subtle differences influence the quality of their social interactions in real-life. Considering the importance of this topic, future research is required to establish the real-world applications of these findings and also investigate how different cognitive abilities, such as working memory, response inhibition etc. influence these processes.

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Appendix A

Experiments 1, 2, and 3 Materials

Experiment 1 (experimental item from one of the 3 lists are included here, but all the items were counterbalanced so each sentence was presented using all 3 pronouns):

1. I am separating waste
2. I am slicing the tomato
3. I am folding the paper
4. I am typing on the laptop
5. I am hammering a nail
6. I am peeling the cucumber
7. I am stapling the paper
8. I am ironing the trousers
9. I am squeezing the lemon
10. I am coring the apple
11. I am taping the package
12. I am tearing the paper
13. I am cutting the steak
14. I am watering the plant
15. I am playing the piano
16. I am feeding the cat
17. I am playing poker
18. I am turning the hourglass
19. I am writing a letter

20. I am reading a book
21. I am plugging in the headphones
22. I am using a walky talky
23. I am arranging flowers
24. I am making a smoothie
25. I am polishing the vase
26. I am cleaning the table
27. I am folding the laundry
28. I am dividing the sweets
29. I am making sushi
30. I am turning on the fan
31. You are putting on gloves
32. You are chopping the carrot
33. You are solving a rubik's cube
34. You are opening the tin
35. You are cleaning the window
36. You are painting your nails
37. You are grabbing a tissue
38. You are holding a mug
39. You are cutting the paper
40. You are riding the bicycle
41. You are hoovering the carpet
42. You are scrubbing the floor

43. You are playing cards
44. You are holding a paracetamol
45. You are catching raindrops
46. You are picking a blueberry
47. You are tying your laces
48. You are sharpening the pencil
49. You are cleaning your glasses
50. You are holding the magnifying glass
51. You are reading maps
52. You are moving the wheelie bin
53. You are connecting the USB stick
54. You are striking the match
55. You are reading the compass
56. You are washing the dishes
57. You are spreading the jam
58. You are serving the wine
59. You are polishing a shoe
60. You are threading the needle
61. He is petting a bunny
62. She is shaking a bottle
63. He is collecting shells
64. She is grating the cheese
65. He is boiling the kettle

66. She is planting the seeds

67. He is crumbling the cookie

68. She is peeling the banana

69. He is drawing a rocket

70. She is salting an egg

71. He is calculating a sum

72. She is stamping the envelope

73. He is opening the beer bottle

74. She is clicking the mouse

75. He is cutting the pineapple

76. She is knitting a scarf

77. He is playing tennis

78. She is trimming the hedge

79. He is assembling furniture

80. She is spraying the garden hose

81. He is toasting the bread

82. She is holding a hand puppet

83. He is making cofee

84. She is milking the goat

85. He is mowing the grass

86. She is spraying perfume

87. He is wringing out the flanel

88. She is making a salad

89. He is taping pages together

90. She is putting on the ring

Experiment 2 (experimental item from one of the 2 lists are included here, but all the items were counterbalanced so each sentence was presented using pronouns 'you' and 'he'):

1. You are a waiter at a restaurant. You are serving a customer. Right now, you are pouring milk (into the glass).
2. You are a coffee shop customer. He is preparing to eat his meal. Right now, he is stirring coffee.
3. He is a postal worker. He is mailing letters. Right now, he is putting on a stamp (on the envelope).
4. You are a kindergarten teacher. You are teaching kids to draw a snowman. Right now, you are drawing a circle (on the paper).
5. You are a librarian. You are checking due dates. Right now, you are opening the book.
6. He is a kitchen helper. He is cleaning up the dining room. Right now, he is wiping the table.
7. You are a grocery owner. You are preparing to open the store. Right now, you are opening a box.
8. You are a mathematician. You are calculating formulas. Right now, you are punching a number on the calculator.

9. He is a grade- school teacher. He is teaching kids to make paper animals. Right now, he is folding coloured paper.
10. He is a house keeper. He is cleaning the floor. Right now, he is squeezing the towel.
11. You are a baker. You are making apple pie. Right now, you are cutting an apple.
12. You are a bartender. You are taking customer orders. Right now, you are opening a bottle.
13. He is a florist. He is arranging a bouquet. Right now, he is holding a vase.
14. You are a tailor. You are making a skirt. Right now, he is cutting some cloth (with scissors).
15. He is a dishwasher. He is cleaning the lunch dishes. Right now, he is wiping a plate.
16. You are a mover. He is cleaning up the room. Right now, you are taping a box.
17. He is a secretary. He is filing documents. Right now, he is stapling the report.
18. You are a card player. You are playing poker. Right now, you are holding the cards.
19. You are a cooking teacher. You are preparing banana bread. Right now, you are peeling a banana.

20. He is a watch repair person. He is fixing a watch. Right now, he is resetting the watch.
21. You are a dentist. You are teaching a patient/someone how to brush teeth. Right now, you are grabbing the toothbrush.
22. You are a professor. You are lecturing on chapter 3 from the textbook. Right now, you are turning the page.
23. You are a carpenter. You are building a shelf. Right now, you are pounding a nail.
24. You are a waiter at a café. You are setting the table. Right now, you are folding a napkin.

Experiment 3 (experimental item from one of the 3 lists are included here, but all the items were counterbalanced so each sentence was presented using all 3 pronouns):

1. You are a 27-year old waiter at a restaurant. You are serving a customer. Right now, you are pouring milk.
2. He is a 51-year old coffee shop customer. He is preparing to eat his meal. Right now, he is stirring the coffee.
3. I am a 44-year old postal worker. I am mailing the letters. Right now, I am putting on the stamp.
4. You are a 31-year old kindergarten teacher. You are teaching kids to draw a snowman. Right now, you are drawing a circle.

5. He is an 18-year old librarian. He is checking due dates. Right now, he is opening the book.
6. I am a 56-year old grocery owner. I am preparing to open the store. Right now, I am opening a box.
7. You are a 35-year old mathematician. You are calculating formulas. Right now, you are punching a number on the calculator
8. He is a 38-year old kitchen helper. He is cleaning up the dining room. Right now, he is wiping the table.
9. I am a 45-year old baker. I am making apple pie. Right now, I am cutting an apple.
10. You are a 26-year old bartender. You are taking customer orders. Right now, you are opening a bottle.
11. He is a 42-year old primary school teacher. He is teaching kids to make paper animals. Right now, he is folding the coloured paper.
12. I am a 23-year old dishwasher. I am cleaning the lunch dishes. Right now, I am wiping a plate.
13. You are a 37-year old florist. You are arranging a bouquet. Right now, you are holding a vase.
14. He is a 32-year old house keeper. He is cleaning the floor. Right now, he is squeezing the towel.
15. I am a 36-year old mover. I am cleaning up the room. Right now, I am taping a box.

16. You are a 53-year old tailor. You are making a skirt. Right now, you are cutting some cloth.
17. He is a 25-year old secretary. He is filing documents. Right now, he is stapling the report.
18. I am a 34-year old card player. I am playing poker. Right now, I am holding the cards.
19. You are a 32-year old dentist. You are teaching a patient how to brush teeth. Right now, you are grabbing the toothbrush.
20. He is a 43-year old watch repair person. He is fixing a watch. Right now, he is resetting the watch.
21. I am a 38-year old cooking teacher. I am preparing banana bread. Right now, I am peeling a banana.
22. You are a 24-year old waiter at a café. You are setting the table. Right now, you are folding a napkin.
23. He is a 56-year old professor. He is lecturing on chapter 3 from the textbook. Right now, he is turning the page.
24. I am a 34-year old carpenter. I am building a shelf. Right now, I am pounding a nail.
25. You are a 34-year old doctor. You are checking patients. Right now, you are checking a patient's blood pressure.
26. He is a 32-year old lawyer. He is researching for a case. Right now, he is reading documents.

27. I am a 28-year old novelist. I am writing a new book. Right now, I am typing the first line.
28. You are a 19-year old photographer. You are taking pictures of cities. Right now, you are changing the lens.
29. He is a 44-year old TV reporter. He is covering a news story. Right now, he is holding a microphone.
30. I am a 51-year old chef. I am preparing for dinner. Right now, I am cutting the carrots.
31. You are a 53-year old ship captain. You are about to dock the ship. Right now, you are holding the steering wheel.
32. He is a 36-year old fisherman. He is fishing at the lake. Right now, he is putting bait on his line.
33. I am a 26-year old mountain climber. I am about to climb Mt. Everest. Right now, I am holding my boots.
34. You are a 21-year old tour guide. You are giving a tour of the city. Right now, you are giving the brochures.
35. He is a 29-year old barber. He has just finished work for the day. Right now, he is sweeping the floor.
36. I am a 41-year old veterinarian. I am checking a sick cat. Right now, I am giving the cat some medicine.

Appendix B

Experiments 4, and 5 Materials (all the items were counterbalanced within each category). Critical words are highlighted in red.

Experiment 4:

Age Category:

1. Usually in the afternoon, I turn on the TV to watch news.
2. I like going to museums to see the dinosaurs.
3. Before going to bed, I like to read a book about fairies.
4. When we go shopping, I usually look for my favourite wine.
5. We go to the leisure centre on Saturdays, to use the spa facility.
6. When I go to parties, I usually wear my Batman costume.
7. Sometimes I get in trouble because I forget to take my homework.
8. On my last birthday, I got an expensive electric shaver.

Gender Category:

1. Before starting my new job, I need to buy a new skirt.
2. The day before my wedding, my friends and I are going to the pub.
3. I saved money for a long time to buy the gold cufflinks.
4. Every Tuesday, I go to the local gym to do Zumba.
5. I like to spend my Sunday at home watching cooking shows.
6. At parties, I usually stick to drinking whiskey.
7. When I was younger, my favourite hobby was rugby.
8. I organise everything in my wardrobe by colour especially my heels.

Class Category:

1. Since I was 25, I have been working as a lawyer.
2. For my son's birthday, I got him a new tracksuit.
3. I never smoke inside, because my wife doesn't like the smell of rollies.
4. I like to travel around the country in my new BMW.
5. Every month, I take my family to watch an opera show.
6. I have always encouraged my son to learn how to play pool.
7. For breakfast, I usually have a hot drink with beans on toast.
8. When I go shopping, I can't resist buying a bottle of brandy.

Experiment 5:

Class Category:

1. On Sundays I always play a game of golf with a few friends.
2. Every Tuesday night my son goes to hockey training.
3. In the evenings I always smoke a zebra after dinner
4. My wife works as a judge in the criminal justice sector.
5. Tomorrow I will go to Mauritius on a relaxing holiday.
6. In recent years I have learned a lot about sharks brands
7. In the summer we often sail with acquaintances.
8. At Christmas I received a nice fountain pen from my wife.
9. Every week I play snacks with friends at the club.
10. In my garage I have a Jaguar with leather upholstery.

11. I need to get my pool cleaned every month.

12. Last week our backpack watered the garden.

13. Last week, after the party my driver drove me home.

14. I can walk around for hours in a museum with modern arts.

15. In our garden we have a waffle court installed professionally.

16. We are going to a gala in Rotterdam tonight.

17. In my spare time I like to listen to piano music by Chopin.

18. Yesterday I bought an original vinegar painting at an auction.

19. Every month, we go to the opera for a night out.

20. My daughter likes to ride her horse through the forest.

21. I like to ride my brush through the city.

22. I like talking to my passengers in the taxi while driving around.

23. I bought a packet of cheap tobacco in the shopping centre.

24. In the evenings I often go to button for fish and chips.

25. When I pop to the supermarket I usually wear my pyjamas and some shoes.

26. After work I like to play darts with colleagues in the pub.

27. Because of work I spend a lot of time in the spice for our company.

28. I like to spend my weekends with my mates drinking on the Pier.

29. I bought snacks and cheap booze for my wife’s birthday party.

30. Before a football match we usually meet in the cat with other supporters

31. In the evenings I work as a cleaner in a 5 star hotel.

32. I usually grab a burger from McDonalds on my lunch break.

33. Since my resignation I have been restaurant for two years.

34. I live in a small rundown house with my husband and kids.

35. We have been living in an old flat for fourteen years now.

36. Yesterday I bought earrings for my air in the market.

37. I usually buy clothes from charity shops for my children.

38. I have a large tattoo on my back.

39. I always spend a lot of money on the comb machine in the café.

40. I always do my shopping at Aldi around the corner.

Age Category:

1. I cannot sleep without my teddy in my arms.
2. My favourite book is the lemonade of Sleeping Beauty.
3. At the fun fair I prefer to go on the roundabout again and again.
4. I like to walk with my doll that has a blue dress.
5. Last week we went on a sneeze trip to Germany with my classmates.
6. Yesterday I was given a skipping rope from my mother.
7. When I go to the beach I like to make sandcastles by the sea.
8. I had a big birthday party in the stew centre with my friends.
9. I drew a flower with my fingers for my mother.
10. I was busy doing my homework yesterday night.
11. Last week I fell off the snore and my knee hurts.
12. At Easter I spent two hours looking for eggs in the garden.
13. At night I am afraid of monsters under my bed.

14. At IKEA I have fun in the lamp pit all afternoon.

15. The best TV program is Sesame Street with Bert and Ernie.

16. I bought a new piggy bank at the toy shop.

17. I am very nervous for the day that melon arrives in the UK.

18. On Sundays I always receive my pocket money from my parents.

19. I sometimes have to stay at school longer to finish my homework.

20. I spent all day on Saturday in the crayon playing football

21. I love to eat spiced olives with garlic.

22. In the morning I always drink two cups of coffee with my breakfast.

23. Yesterday I went to a hamster evening at my daughter's school.

24. Last night I forgot my wallet when I went grocery shopping.

25. Last year I got married in a beautiful castle.

26. Yesterday I carefully plate to my mother's house by car.

27. Finally last year I got my driving license in the summer.

28. I drink a glass of wine every night before I go to sleep.

29. I painted my syllables room with yellow paint.

30. Tomorrow I will cook for a few friends.

31. I like to drink a big glass of beer when I am out with friends.

32. Yesterday I taught my eldest map how to cycle.

33. I painted my daughter's room with yellow paint.

34. On Saturdays my wife and I go for a walk in the forest.

35. I always read the honeycomb before I go to work.

36. I keep planning to quit smoking after the holidays.

37. I like to drive my lorry through the countryside.

38. On Saturday nights I always go carrying with a few friends.

39. I have to fly to London every two weeks.

40. I have decided to work less and take more time off.

Gender Category:

1. Every week I trim my whale with a small pair of scissors.
2. I always have to wear a tie with the logo of Shell for my work.
3. While cleaning up, I found my playboy magazines under the cupboard.
4. I broke my ankle while riding my calculator late at night.
5. After high school, I started working as a bricklayer in construction.
6. When I have to park the van, I always look for a free parking space.
7. I want to turn my car into a shrimp car so it can go faster.
8. Every Friday evening I play rugby with a group of colleagues.
9. Last Wednesday I cleaned my shotgun for when I go hunting.
10. While watching a football match I usually prawn and gesture at the TV.
11. While moving houses, I carried the dishwasher up the stairs.
12. I got home late as I was playing billiards with friends.
13. I spent a few years toothpick at a local gym
14. On my birthday, I got a bottle of whiskey from my best friend.
15. Last year I built a dormer on our new house.
16. I always rent films with a lot of trousers at the video store.
17. Every Saturday night I work as a bouncer at a night club.

18. I almost always wear a bowtie at formal parties.

19. I have worked as a kangaroo at the local garage for years.

20. For my best friend’s stag we went to a strip club in Amsterdam

21. For the past hour I have been fixing the pipes under the sink.

22. I was busy fixing my astronaut all Saturday afternoon.

23. I really like my job in the navy because I get to travel often.

24. Of course, as a security guard, I am responsible for the safety of guests.

25. I almost always have a bottle of chimney in my pocket.

26. I immediately turned off my soldering iron as soon as I got the call.

27. The day starts nicely when I drive my tractor through the farm.

28. I used to be a famous hotpot, but that's a thing of the past.

29. When I am in the US I always watch a baseball match in the stadium.

30. I was just laying the floor when the bell rang.

31. At school I am responsible for the margarine and internet connections.

32. When I win the lottery, I will buy an expensive car with all the trimmings.

33. When I go out for dinner, I always order ribs with extra chips.

34. Because I work as an onion, I get to travel to different countries.

35. When I'm free, I often go to watch motocross in different places.

36. I have a large poster of a racing car hanging above my desk.

37. Just before the checkout I dropped my roundabout on the floor.

38. When I want to relax, I go fishing on the canal near my house.

39. I prefer to watch the sports on the TV in a pub.

40. In my attic I have a whole collection of health in big boxes.
41. I would like to buy a gold necklace for my wedding.
42. I tried to refresh my lipstick in front of the mirror.
43. At the gala I wore a spinach dress with sparkly shoes.
44. Yesterday, the hairdresser permed my hair and trimmed it a bit.
45. I spent my day off in a beauty salon near the river.
46. Before leaving the house, I always check my cookie to make sure I look my best.
47. My favourite piece of clothing is a denim skirt with flowers on it.
48. For my birthday I got a nice brooch with a gemstone on it.
49. I usually wear a ship suit when I have an important presentation.
50. Unfortunately my favourite heels broke when I was running to get the bus.
51. As a child I used to have ballet lessons every week for a long time.
52. I regularly get my nails spaghetti from a nails salon in the city centre.
53. When I go out, I prefer to wear stilettos with my outfit.
54. When the weather is nice, I like to lie in my bikini in the garden.
55. For Christmas I made an insect arrangement for the table.
56. When I pass the shopping centre, I often buy new dresses that I don't need.
57. When I go to the pool, I always take my pink bathing suit with me.
58. In my spare time I paper a blue dress for my mother.
59. I put little effort into understanding the knitting patterns I needed.

60. I saved money to buy a sewing machine with an automatic needle threader.
61. I bought a very comfortable ear from an expensive shop.
62. I usually start crying when watching romantic movies with sad-endings.
63. I had to go to the chemist because my mascara completely dried out.
64. Every Wednesday I go to computer in the sports hall.
65. I always have some change in my purse to pay the bus fare.
66. I work as a professional pedicurist in a beauty centre in town.
67. I love to spend the weekends blackboard with my girlfriends in the shopping mall.
68. I work as an assistant in a nursery and I love my job.
69. I watch my favourite drama shows on TV every day.
70. My favourite programs are always about sweater or interior design.
71. I had to go to the store to buy face masks and a bag of cat litter.
72. My favourite colours are pink and apple green.
73. Unfortunately there was a huge hole in my jungle and I didn't have a spare pair.
74. I wish I looked like Beyonce in her latest music video.
75. Before going to the beach, I always shave my legs with a razor.
76. After taking a shower I grabbed the chicken iron to do my hair.
77. I often enjoy a long, relaxing bath after playing tennis.
78. My favourite colour of nail polish is bright orange.
79. I like to buy museum bedsheets for my room.

80. I can spend hours talking on the phone with my friends.

Appendix C

Experiment 6 Materials:

Full set of experimental items in each condition. Note that for each of the items below, conditions are listed in the order: Ironic Victim Positive, Literal Victim Positive, Ironic Protagonist Positive, Literal Protagonist Positive, Ironic Victim Negative, Literal Victim Negative, Ironic Protagonist Negative, Literal Protagonist Negative.

1

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, "That was fantastic parking". Sandra was really amused by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, "That was horrendous parking". Sandra was really amused by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was fantastic parking”. Harriet had intended for her to be really amused by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was horrendous parking”. Harriet had intended for her to be really amused by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was fantastic parking”. Sandra was really hurt by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was horrendous parking”. Sandra was really hurt by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was fantastic parking”. Harriet had intended for her to be really hurt by what she said.

Sandra had misjudged the distance when reversing into the space and bumped into the car behind her. Harriet said to her, “That was horrendous parking”. Harriet had intended for her to be really hurt by what she said.

2

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are amazing at this”. Milly thought that this was a very humorous comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are dreadful at this”. Milly thought that this was a very humorous comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are amazing at this”. Charlotte had meant for this to be a very humorous comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are dreadful at this”. Charlotte had meant for this to be a very humorous comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are amazing at this”. Milly thought that this was a very unkind comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are dreadful at this”. Milly thought that this was a very unkind comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are amazing at this”. Charlotte had meant for this to be a very unkind comment.

Milly, who was a beginner at tennis, kept hitting the ball into the net. Charlotte announced, “You are dreadful at this”. Charlotte had meant for this to be a very unkind comment.

3

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What brilliant taste in music you have”. Carrie thought that this was a very funny thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Carrie thought that this was a very funny thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Joanne had intended for this to be a very funny thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Joanne had intended for this to be a very funny thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What brilliant taste in music you have”. Carrie thought that this was a very mean thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Carrie thought that this was a very mean thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Joanne had intended for this to be a very mean thing to say.

Carrie commented on how much she loved the song that was playing on the radio. Joanne rolled her eyes and sneered, “What awful taste in music you have”. Joanne had intended for this to be a very mean thing to say.

4

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was intelligent”. Nicola was really entertained by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was stupid”. Nicola was really entertained by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was intelligent”. Ellen had meant for her to be really entertained by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was stupid”. Ellen had meant for her to be really entertained by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was intelligent”. Nicola was really offended by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was stupid”. Nicola was really offended by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was intelligent”. Ellen had meant for her to be really offended by this statement.

Nicola had just made Ellen a cup of tea, but tripped and spilt it all over the living room carpet. Ellen snapped at her, “That was stupid”. Ellen had meant for her to be really offended by this statement.

5

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Excellent time keeping”. Hannah was really tickled by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Poor time keeping”. Hannah was really tickled by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Excellent time keeping”. Bryony had intended for her to be really tickled by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Poor time keeping”. Bryony had intended for her to be really tickled by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Excellent time keeping”. Hannah was really upset by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Poor time keeping”. Hannah was really upset by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Excellent time keeping”. Bryony had intended for her to be really upset by what she said.

Hannah tumbled into class fifteen minutes late, but managed to find a seat next to Bryony. Bryony muttered, “Poor time keeping”. Bryony had intended for her to be really upset by what she said.

6

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look good”. Maddie thought that this was a very witty comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look bad”. Maddie thought that this was a very witty comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look good”. Cheryl had meant for this to be a very witty comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look bad”. Cheryl had meant for this to be a very witty comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look good”. Maddie thought that this was a very cruel comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look bad”. Maddie thought that this was a very cruel comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look good”. Cheryl had meant for this to be a very cruel comment.

Maddie had forgotten about the buns and when she took them out of the oven, they were badly burnt. Cheryl said to her, “They look bad”. Cheryl had meant for this to be a very cruel comment.

7

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look happy”. Laura thought that this was a very comical thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look miserable”. Laura thought that this was a very comical thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look happy”. Chloe had intended for this to be a very comical thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look miserable”. Chloe had intended for this to be a very comical thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look happy”. Laura thought that this was a very cruel thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look miserable”. Laura thought that this was a very cruel thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look happy”. Chloe had intended for this to be a very cruel thing to say.

Laura had just arrived home from work and slammed the front door loudly after a bad day. Chloe said to her, “You look miserable”. Chloe had intended for this to be a very cruel thing to say.

8

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was intelligent”. Amber was really tickled by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was dumb”. Amber was really tickled by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was intelligent”. Jan had meant for her to be really tickled by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was dumb”. Jan had meant for her to be really tickled by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was intelligent”. Amber was really offended by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was dumb”. Amber was really offended by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was intelligent”. Jan had meant for her to be really offended by this statement.

Amber had been watching a game show on television and got the answer to a simple question completely wrong. Jan said to her, “That was dumb”. Jan had meant for her to be really offended by this statement.

9

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the best bartender ever”. Charles was really amused by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the worst bartender ever”. Charles was really amused by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the best bartender ever”. Phil had intended for him to be really amused by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the worst bartender ever”. Phil had intended for him to be really amused by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the best bartender ever”. Charles was really upset by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the worst bartender ever”. Charles was really upset by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the best bartender ever”. Phil had intended for him to be really upset by what he said.

As Charles picked up the glass, it shattered in his hand and pieces flew across the bar floor. Phil jeered, “You are the worst bartender ever”. Phil had intended for him to be upset hurt by what he said.

10

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Outstanding shooting today Aaron”. Aaron was really entertained by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Dreadful shooting today Aaron”. Aaron was really entertained by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Outstanding shooting today Aaron”. Richard had meant for him to be really entertained by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Dreadful shooting today Aaron”. Richard had meant for him to be really entertained by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Outstanding shooting today Aaron”. Aaron was really insulted by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Dreadful shooting today Aaron”. Aaron was really insulted by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Outstanding shooting today Aaron”. Richard had meant for him to be really insulted by this statement.

Aaron missed the final penalty of the penalty shoot-out, causing his team to lose. Richard announced, “Dreadful shooting today Aaron”. Richard had meant for him to be really insulted by this statement.

11

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a fabulous day this has been”. Eric thought that this was a very hilarious comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a horrendous day this has been”. Eric thought that this was a very hilarious comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a fabulous day this has been”. Ross had meant for this to be a very hilarious comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped him, “What a horrendous day this has been”. Ross had meant for this to be a very hilarious comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a fabulous day this has been”. Eric thought that this was a very insensitive comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a horrendous day this has been”. Eric thought that this was a very insensitive comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped at him, “What a fabulous day this has been”. Ross had meant for this to be a very insensitive comment.

Whilst Eric was unloading his food shopping, a box of eggs smashed on the floor. Ross snapped him, “What a horrendous day this has been”. Ross had meant for this to be a very insensitive comment.

12

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What an outstanding grade”. Barney thought that this was a very funny comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What a terrible grade”. Barney thought that this was a very funny comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What an outstanding grade”. Henry had meant for this to be a very funny comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What a terrible grade”. Henry had meant for this to be a very funny comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What an outstanding grade”. Barney thought that this was a very unkind comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What a terrible grade”. Barney thought that this was a very unkind comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What an outstanding grade”. Henry had meant for this to be a very unkind comment.

Barney had just received his essay grade and was disappointed that he scraped a pass. Harry said to him, “What a terrible grade”. Henry had meant for this to be a very unkind comment.

13

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so strong”. Charlie thought that this was a very hilarious thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so weak”. Charlie thought that this was a very hilarious thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so strong”. Ray had intended for this to be a very hilarious thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so weak”. Ray had intended for this to be a very hilarious thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so strong”. Charlie thought that this was a very hurtful thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so weak”. Charlie thought that this was a very hurtful thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so strong”. Ray had intended for this to be a very hurtful thing to say.

Charlie was desperately trying to open the lid of a jar but was having difficulty opening it. Ray said to him, “Youíre so weak”. Ray had intended for this to be a very hurtful thing to say.

14

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so energetic”. Brendan was really tickled by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so lazy”. Brendan was really tickled by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so energetic”. Patrick had meant for him to be really tickled by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so lazy”. Patrick had meant for him to be really tickled by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so energetic”. Brendan was really upset by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so lazy”. Brendan was really upset by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so energetic”. Patrick had meant for him to be really upset by this statement.

Brendan had decided after ten minutes that he couldnít be bothered to exercise any longer. Patrick said to him, “Youíre so lazy”. Patrick had meant for him to be really upset by this statement.

15

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look wonderful”. Phillip was really amused by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look dreadful”. Phillip was really amused by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look wonderful”. Karl had intended for him to be really amused by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look dreadful”. Karl had intended for him to be really amused by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look wonderful”. Phillip was really offended by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look dreadful”. Phillip was really offended by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look wonderful”. Karl had intended for him to be really offended by what he said.

Phillip had been putting shelves up for an hour when he noticed they were a bit wonky and uneven. Karl said to him, “They look dreadful”. Karl had intended for him to be really offended by what he said.

16

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How generous of you”. Henry thought that this was a very humorous thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How stingy of you”. Henry thought that this was a very humorous thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How generous of you”. Louis had intended for this to be a very humorous thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How stingy of you”. Louis had intended for this to be a very humorous thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How generous of you”. Henry thought that this was a very insensitive thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How stingy of you”. Henry thought that this was a very insensitive thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How generous of you”. Louis had intended for this to be a very insensitive thing to say.

Henry had decided he wasnít going to buy anybody Christmas or birthday presents this year. Louis said to him, “How stingy of you”. Louis had intended for this to be a very insensitive thing to say.

17

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Excellent coordination Erica”. Erica thought that this was a very witty thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Rubbish coordination Erica”. Erica thought that this was a very witty thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Excellent coordination Erica”. Neil had intended for this to be a very witty thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Rubbish coordination Erica”. Neil had intended for this to be a very witty thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Excellent coordination Erica”. Erica thought that this was a very mean thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Rubbish coordination Erica”. Erica thought that this was a very mean thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Excellent coordination Erica”. Neil had intended for this to be a very mean thing to say.

Erica reached across to put her phone into her bag, but misjudged the distance and smashed her phone. Neil announced, “Rubbish coordination Erica”. Neil had intended for this to be a very mean thing to say.

18

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was an intelligent thing to do”. Holly was really entertained by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was a stupid thing to do”. Holly was really entertained by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was an intelligent thing to do”. Adam had meant for her to be really entertained by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was a stupid thing to do”. Adam had meant for her to be really entertained by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was an intelligent thing to do”. Holly was really insulted by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was a stupid thing to do”. Holly was really insulted by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was an intelligent thing to do”. Adam had meant for her to be really insulted by this statement.

When Holly returned her book a week late, she was shocked at how much the library fine was. Adam said, “That was a stupid thing to do”. Adam had meant for her to be really insulted by this statement.

19

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most organised person I know”. Stephanie was really entertained by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most chaotic person I know”. Stephanie was really entertained by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most organised person I know”. Theo had intended for her to be really entertained by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most chaotic person I know”. Theo had intended for her to be really entertained by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most organised person I know”. Stephanie was really insulted by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most chaotic person I know”. Stephanie was really insulted by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most organised person I know”. Theo had intended for her to be really insulted by what he said.

Stephanie arrived for her swimming lesson, but realised she had forgotten her swimsuit. Theo scoffed at her, “You are the most chaotic person I know”. Theo had intended for her to be really inulted by what he said.

20

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look intelligent”. Katie thought that this was a very comical comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look dumb”. Katie thought that this was a very comical comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look intelligent”. Jack had meant for this to be a very comical comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look dumb”. Jack had meant for this to be a very comical comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look intelligent”. Katie thought that this was a very unkind comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look dumb”. Katie thought that this was a very unkind comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look intelligent”. Jack had meant for this to be a very unkind comment.

Katie was pondering over some difficult maths homework, when the pen she was chewing exploded in her mouth. Jack snorted, “You look dumb”. Jack had meant for this to be a very unkind comment.

21

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an amazing driver you are”. Hazel thought that this was a very funny comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an awful driver you are”. Hazel thought that this was a very funny comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an amazing driver you are”. George had meant for this to be a very funny comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an awful driver you are”. George had meant for this to be a very funny comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an amazing driver you are”. Hazel thought that this was a very cruel comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an awful driver you are”. Hazel thought that this was a very cruel comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an amazing driver you are”. George had meant for this to be a very cruel comment.

Hazel had just broken the news that she had failed her third driving test. George jeered, “We all know what an awful driver you are”. George had meant for this to be a very cruel comment.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was interesting”. Natalie thought that this was a very humorous thing to say.

22

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was dull”. Natalie thought that this was a very humorous thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was interesting”. Jake had intended for this to be a very humorous thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was dull”. Jake had intended for this to be a very humorous thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was interesting”. Natalie thought that this was a very insensitive thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was dull”. Natalie thought that this was a very insensitive thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was interesting”. Jake had intended for this to be a very insensitive thing to say.

Natalie had been boring her friends talking about an uninteresting work story. Jake said to her, “Well that was dull”. Jake had intended for this to be a very insensitive thing to say.

23

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was friendly”. Jo was really amused by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was rude”. Jo was really amused by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was friendly”. Gus had intended for her to be really amused by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was rude”. Gus had intended for her to be really amused by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was friendly”. Jo was really hurt by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was rude”. Jo was really hurt by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was friendly”. Gus had intended for her to be really hurt by what he said.

Jo had just purposefully ignored some of her friends at a party because she didnít feel like talking to them. Gus said to her, “That was rude”. Gus had intended for her to be really hurt by what he said.

24

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre amazing at bowling”. Olive was really tickled by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre horrendous at bowling”. Olive was really tickled by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre amazing at bowling”. Luke had meant for her to be really tickled by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre horrendous at bowling”. Luke had meant for her to be really tickled by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre amazing at bowling”. Olive was really insulted by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre horrendous at bowling”. Olive was really insulted by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre amazing at bowling”. Luke had meant for her to be really insulted by this statement.

Olive had finished with the worst score in the game of bowling, like she always did. Luke said to her, “Youíre horrendous at bowling”. Luke had meant for her to be really insulted by this statement.

25

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are fantastic at taking care of your belongings”. Ben thought that this was a very hilarious thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are dreadful at taking care of your belongings”. Ben thought that this was a very hilarious thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are fantastic at taking care of your belongings”. Annie had intended for this to be a very hilarious thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are dreadful at taking care of your belongings”. Annie had intended for this to be a very hilarious thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are fantastic at taking care of your belongings”. Ben thought that this was a very unkind thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are dreadful at taking care of your belongings”. Ben thought that this was a very unkind thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are fantastic at taking care of your belongings”. Annie had intended for this to be a very unkind thing to say.

Ben began to panic when he realised he left his music player at the gym. Annie retorted, “You are dreadful at taking care of your belongings”. Annie had intended for this to be a very unkind thing to say.

26

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really love pink woolly jumpers”. Brian thought that this was a very comical comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really hate pink woolly jumpers”. Brian thought that this was a very comical comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really love pink woolly jumpers”. Tiffany had meant for this to be a very comical comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really hate pink woolly jumpers”. Tiffany had meant for this to be a very comical comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really love pink woolly jumpers”. Brian thought that this was a very mean comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really hate pink woolly jumpers”. Brian thought that this was a very mean comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really love pink woolly jumpers”. Tiffany had meant for this to be a very mean comment.

Brian thought his choice of present for Tiffany was perfect. When Tiffany opened the present she scoffed, “I really hate pink woolly jumpers”. Tiffany had meant for this to be a very mean comment.

27

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an excellent sportsman”. Thomas thought that this was a very witty thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an awful sportsman”. Thomas thought that this was a very witty thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an excellent sportsman”. Sarah had intended for this to be a very witty thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an awful sportsman”. Sarah had intended for this to be a very witty thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an excellent sportsman”. Thomas thought that this was a very hurtful thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an awful sportsman”. Thomas thought that this was a very hurtful thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an excellent sportsman”. Sarah had intended for this to be a very hurtful thing to say.

Thomas had been admitted to hospital with a fractured leg after tripping over his hockey stick. Sarah sniggered, “What an awful sportsman”. Sarah had intended for this to be a very hurtful thing to say.

28

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be delighted to spend our holiday in England”. Samuel thought that this was a very hilarious comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be devastated to spend our holiday in England”. Samuel thought that this was a very hilarious comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be delighted to spend our holiday in England”. Maria had meant for this to be a very hilarious comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be devastated to spend our holiday in England”. Maria had meant for this to be a very hilarious comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be delighted to spend our holiday in England”. Samuel thought that this was a very cruel comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be devastated to spend our holiday in England”. Samuel thought that this was a very cruel comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be delighted to spend our holiday in England”. Maria had meant for this to be a very cruel comment.

When Samuel joined the check-in queue, he realised he had left his passport at home. Maria snapped at him, “Iíd be devastated to spend our holiday in England”. Maria had meant for this to be a very cruel comment.

29

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be good for my teeth”. John was really amused by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be bad for my teeth”. John was really amused by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be good for my teeth”. Mary had intended for him to be really amused by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be bad for my teeth”. Mary had intended for him to be really amused by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be good for my teeth”. John was really offended by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be bad for my teeth”. John was really offended by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be good for my teeth”. Mary had intended for him to be really offended by what she said.

John, baked cookies for the first time and they were rock hard. Mary told him, “Oh these will be bad for my teeth”. Mary had intended for him to be really offended by what she said.

30

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a great barber”. Jane was really entertained by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a terrible barber”. Jane was really entertained by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a great barber”. Julia had meant for her to be really entertained by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a terrible barber”. Julia had meant for her to be really entertained by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a great barber”. Jane was really insulted by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a terrible barber”. Jane was really insulted by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a great barber”. Julia had meant for her to be really insulted by this statement.

Jane decided to cut her fringe herself but she got distracted and cut it uneven. Julia told her, “Well, you will be a terrible barber”. Julia had meant for her to be really insulted by this statement.

31

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was skilful”. Jack thought that this was a very comical thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was unskilful”. Jack thought that this was a very comical thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was skilful”. Mike had intended for this to be a very comical thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was unskilful”. Mike had intended for this to be a very comical thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was skilful”. Jack thought that this was a very insensitive thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was unskilful”. Jack thought that this was a very insensitive thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was skilful”. Mike had intended for this to be a very insensitive thing to say.

Jack who has just started playing football, accidentally scored an own goal. Mike told him, “Oh that was unskilful”. Mike had intended for this to be a very insensitive thing to say.

32

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so strong”. Josh thought that this was a very humorous comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so weak”. Josh thought that this was a very humorous comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so strong”. Louise Josh had meant for this to be a very humorous comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so weak”. Louise had meant for this to be a very humorous comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so strong”. Josh thought that this was a very unkind comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so weak”. Josh thought that this was a very unkind comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so strong”. Louise had meant for this to be a very unkind comment.

Josh is at the carpentry class, and has been trying to saw a piece of wood for the past hour. Louise came over and said to him, “Wow youíre so weak”. Louise had meant for this to be a very unkind comment.

33

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so careful”. Chloe was really tickled by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so clumsy”. Chloe was really tickled by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so careful”. Amy had intended for her to be really tickled by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so clumsy”. Amy had intended for her to be really tickled by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so careful”. Chloe was really offended by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so clumsy”. Chloe was really offended by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so careful”. Amy had intended for her to be really offended by what she said.

Chloe was washing the dishes after dinner, when she suddenly dropped a few plates and they broke. Amy told her, “Youíre so clumsy”. Amy had intended for her to be really offended by what she said.

34

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a smart move”. Daniel thought that this was a very funny thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a stupid move”. Daniel thought that this was a very funny thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a smart move”. Danielís colleague had intended for this to be a very funny thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a stupid move”. Danielís colleague had intended for this to be a very funny thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a smart move”. Daniel thought that this was a very cruel thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a stupid move”. Daniel thought that this was a very cruel thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a smart move”. Danielís colleague had intended for this to be a very cruel thing to say.

Daniel was pouring a glass of red wine for his boss when he accidentally spilled a few drops on her white shirt. Danielís colleague told him, “That was a stupid move”. Danielís colleague had intended for this to be a very cruel thing to say.

35

Courtneyí’S neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have an amazing memory”. Courtney thought that this was a very witty thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have a horrendous memory”. Courtney thought that this was a very witty thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have an amazing memory”. David had intended for this to be a very witty thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have a horrendous memory”. David had intended for this to be a very witty thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have an amazing memory”. Courtney thought that this was a very mean thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have a horrendous memory”. Courtney thought that this was a very mean thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have an amazing memory”. David had intended for this to be a very mean thing to say.

Courtneyís neighbour asked her to water his plants while he was away, but Courtney completely forgot and all the plants died. David told her, “You have a horrendous memory”. David had intended for this to be a very mean thing to say.

36

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useful thing to buy her”. Kelly thought that this was a very hilarious comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useless thing to buy her”. Kelly thought that this was a very hilarious comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useful thing to buy her”. Elizabeth had meant for this to be a very hilarious comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useless thing to buy her”. Elizabeth had meant for this to be a very hilarious comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useful thing to buy her”. Kelly thought that this was a very insensitive comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useless thing to buy her”. Kelly thought that this was a very insensitive comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useful thing to buy her”. Elizabeth had meant for this to be a very insensitive comment.

Kelly bought some sweets to bring to her diabetic friend who had just been discharged from hospital. Elizabeth told her, “Well thatís a useless thing to buy her”. Elizabeth had meant for this to be a very insensitive comment.

37

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so smooth”. Chris was really amused by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so awkward”. Chris was really amused by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so smooth”. Andy had intended for him to be really amused by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so awkward”. Andy had intended for him to be really amused by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so smooth”. Chris was really upset by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so awkward”. Chris was really upset by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so smooth”. Andy had intended for him to be really upset by what he said.

Chris tripped over a table while he was staring at his crush in Biology class. Andy told him, “You are so awkward”. Andy had intended for him to be really upset by what he said.

38

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careful”. Anne was really entertained by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careless”. Anne was really entertained by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careful”. Roger had meant for her to be really entertained by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careless”. Roger had meant for her to be really entertained by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careful”. Anne was really offended by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careless”. Anne was really offended by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careful”. Roger had meant for her to be really offended by this statement.

Anne was helping her grandmother with walking as she has a bad leg, but she slipped on the snow and fell. Roger told her, “You are so careless”. Roger had meant for her to be really offended by this statement.

39

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very polite”. Isabell thought that this was a very witty thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very rude”. Isabell thought that this was a very witty thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very polite”. Lindsey had intended for this to be a very witty thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very rude”. Lindsey had intended for this to be a very witty thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very polite”. Isabell thought that this was a very cruel thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very rude”. Isabell thought that this was a very cruel thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very polite”. Lindsey had intended for this to be a very cruel thing to say.

Isabell was having dinner with some friends but she kept checking her phone because her daughter was texting her. Lindsey told her, “You are very rude”. Lindsey had intended for this to be a very cruel thing to say.

40

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very friendly thing to do”. Adam thought that this was a very comical comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very unfriendly thing to do”. Adam thought that this was a very comical comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very friendly thing to do”. Harry had meant for this to be a very comical comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very unfriendly thing to do”. Harry had meant for this to be a very comical comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very friendly thing to do”. Adam thought that this was a very unkind comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very unfriendly thing to do”. Adam thought that this was a very unkind comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very friendly thing to do”. Harry had meant for this to be a very unkind comment.

Adam was saying hi to everyone at work but he skipped the new colleague as he couldnít remember his name. Harry said to him, “that was a very unfriendly thing to do”. Harry had meant for this to be a very unkind comment.

41

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the wisest person I know”. Leo was really tickled by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the most foolish person I know”. Leo was really tickled by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the wisest person I know”. Olivia had intended for him to be really tickled by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the most foolish person I know”. Olivia had intended for him to be really tickled by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the wisest person I know”. Leo was really upset by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the most foolish person I know”. Leo was really upset by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the wisest person I know”. Olivia had intended for him to be really upset by what she said.

Leo bought some meat for the BBQ party but he forgot to put it in the fridge and the meat went off. Olivia told him, “you are the most foolish person I know”. Olivia had intended for him to be really upset by what she said.

42

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the safest driver I know”. Emily thought that this was a very hilarious thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the most irresponsible driver I know”. Emily thought that this was a very hilarious thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the safest driver I know”. Lily had intended for this to be a very hilarious thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the most irresponsible driver I know”. Lily had intended for this to be a very hilarious thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the safest driver I know”. Emily thought that this was a very insensitive thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the most irresponsible driver I know”. Emily thought that this was a very insensitive thing to say.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the safest driver I know”. Lily had intended for this to be a very insensitive thing to.

Emily was driving her friend to university but she didnít see the speed bump so didnít reduce her speed and both of them bounced into the air. Lily told her, “Arenít you the most irresponsible driver I know”. Lily had intended for this to be a very insensitive thing to say.

43

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how nice of you”. Charlie thought that this was a very funny thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how mean of you”. Charlie thought that this was a very funny thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how nice of you”. Oscar had intended for this to be a very funny thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how mean of you”. Oscar had intended for this to be a very funny thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how nice of you”. Charlie thought that this was a very mean thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how mean of you”. Charlie thought that this was a very mean thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how nice of you”. Oscar had intended for this to be a very mean thing to say.

Charlie had to catch a flight in rush so he didnít have time to wash his dirty dishes and left them in the sink. Oscar said to him, “Oh how mean of you”. Oscar had intended for this to be a very mean thing to say.

44

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a great shopper, arenít you?”. Jacob thought that this was a very comical comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a terrible shopper, arenít you?”. Jacob thought that this was a very comical comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a great shopper, arenít you?”. Oscar had meant for this to be a very comical comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youëre a terrible shopper, arenít you?”. Oscar had meant for this to be a very comical comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a great shopper, arenít you?”. Jacob thought that this was a very cruel comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a terrible shopper, arenít you?”. Jacob thought that this was a very cruel comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a great shopper, arenít you?”. Oscar had meant for this to be a very cruel comment.

Jacob went to the market to do the grocery shopping but he didnít look carefully and bought apples that were full of brown spots. Isabella told him, “Youíre a terrible shopper, arenít you?”. Oscar had meant for this to be a very cruel comment.

45

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so organised”. Amelia was really tickled by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so disorganised”. Amelia was really tickled by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so organised”. Ava had intended for her to be really tickled by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so disorganised”. Ava had intended for her to be really tickled by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so organised”. Amelia was really insulted by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so disorganised”. Amelia was really insulted by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so organised”. Ava had intended for her to be really insulted by what she said.

Amelia and Ava had just arrived at the theatre when Amelia realised she had forgotten the tickets so they didnít get to see the play. Ava said to her, “Youíre so disorganised”. Ava had intended for her to be really insulted by what she said.

46

George arrived home after a long and hot day working in the field, feeding the cows and cleaning the barn. Oliver told him, “You smell nice”. George though that this was a really witty remark.

George arrived home after a long and hot day working in the field, he took off his shoes and sat on the sofa. Oliver told him, “You smell terrible”. George though that this was a really witty remark.

George arrived home after a long and hot day working in the field, feeding the cows and cleaning the barn. Oliver told him, “You smell nice”. Oliver had meant for this to be a very witty remark.

George arrived home after a long and hot day working in the field, he took off his shoes and sat on the sofa. Oliver told him, “You smell terrible”. Oliver had meant for this to be a very witty remark.

George arrived home after a long and hot day working in the field, feeding the cows and cleaning the barn. Oliver told him, “You smell nice”. George though that this was a really hurtful remark.

George arrived home after a long and hot day working in the field, he took off his shoes and sat on the sofa. Oliver told him, “You smell terrible”. George though that this was a really hurtful remark.

George arrived home after a long and hot day working in the field, feeding the cows and cleaning the barn. Oliver told him, “You smell nice”. Oliver had meant for had meant for this to be a very hurtful remark.

George arrived home after a long and hot day working in the field, he took off his shoes and sat on the sofa. Oliver told him, “You smell terrible”. Oliver had meant for this to be a very hurtful remark.

47

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtful husband”. Arthur thought that this was a very humorous thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtless husband”. Arthur thought that this was a very humorous thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtful husband”. Grace had intended for this to be a very humorous thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtless husband”. Grace had intended for this to be a very humorous thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtful husband”. Arthur thought that this was a very insulting thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtless husband”. Arthur thought that this was a very insulting thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtful husband”. Grace had intended for this to be a very insulting thing to say.

Arthur arrived home and saw the calendar on the table and realised that itís his wifeís birthday today and he has forgotten it. Grace said to him, “Youíre the most thoughtless husband”. Grace had intended for this to be a very insulting thing to say.

48

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such an eco-friendly thing to do”. Sophie thought that this was a very funny remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such a wasteful thing to do”. Sophie thought that this was a very funny remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such an eco-friendly thing to do”. Ella had meant for this to be a very funny remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such a wasteful thing to do”. Ella had meant for this to be a very funny remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such an eco-friendly thing to do”. Sophie thought that this was a very hurtful remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such a wasteful thing to do”. Sophie thought that this was a very hurtful remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such an eco-friendly thing to do”. Ella had meant for this to be a very hurtful remark.

Sophie cleaned up after dinner and accidentally put the glass jar in the food waste bin. Ella told her, “That was such a wasteful thing to do”. Ella had meant for this to be a very hurtful remark.

49

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very sensible driver”. Henry thought that this was a very amusing remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very reckless driver”. Henry thought that this was a very amusing remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very sensible driver”. Logan had meant for this to be a very amusing remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very reckless driver”. Logan had meant for this to be a very amusing remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very sensible driver”. Henry thought that this was a very unkind remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very reckless driver”. Henry thought that this was a very unkind remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very sensible driver”. Logan had meant for this to be a very unkind remark.

Henry and Logan were driving to the train station but they were late so Henry ran through a red traffic light. Logan told him, “Youíre a very reckless driver”. Logan had meant for this to be a very unkind remark.

50

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very attentive man”. Duncan was really entertained by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very inattentive man”. Duncan was really entertained by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very attentive man”. Holly had meant for him to be really entertained by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very inattentive man”. Holly had meant for him to be really entertained by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very attentive man”. Duncan was really offended by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very inattentive man”. Duncan was really offended by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very attentive man”. Holly had meant for him to be really offended by this statement.

Duncan and his wife are having dinner, but he hasnít noticed that she has had her hair cut. Holly told him, “Youíre a very inattentive man”. Holly had meant for him to be really offended by this statement.

51

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a nice thing to do”. Emma thought that this was a very humorous remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a terrible thing to do”. Emma thought that this was a very humorous remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a nice thing to do”. Lauren had meant for this to be a very humorous remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a terrible thing to do”. Lauren had meant for this to be a very humorous remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a nice thing to do”. Emma thought that this was a very insensitive remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a terrible thing to do”. Emma thought that this was a very insensitive remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a nice thing to do”. Lauren had meant for this to be a very insensitive remark.

Emma and Lauren were driving home from work on a rainy day when Emma drove through puddle and splashed some pedestrians. Lauren said to her, “That was a terrible thing to do”. Lauren had meant for this to be a very insensitive remark.

52

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a smart thing to do”. Charlie thought that this was a very comical remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a stupid thing to do”. Charlie thought that this was a very comical remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a smart thing to do”. Eric had meant for this to be a very comical remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a stupid thing to do”. Eric had meant for this to be a very comical remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a smart thing to do”. Charlie thought that this was a very upsetting remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a stupid thing to do”. Charlie thought that this was a very upsetting remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a smart thing to do”. Eric had meant for this to be a very upsetting remark.

Charlie and Eric came back from a night out and realised that Charlie had left his keys in the door. Charlie said to him, “That was such a stupid thing to do”. Eric had meant for this to be a very upsetting remark.

53

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was intelligent”. Martin was really entertained by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was dumb”. Martin was really entertained by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was intelligent”. Christina had entertained for him to be really entertained by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was dumb”. Christina had intended for him to be really entertained by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was intelligent”. Martin was really insulted by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was dumb”. Martin was really insulted by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was intelligent”. Christina had intended for him to be really insulted by what she said.

Martin had made a cake but had accidently put four times the amount of salt in than he should have. Christina said to him, “That was dumb”. Christina had intended for him to be really insulted by what she said.

54

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so kind”. Terry was really entertained by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so mean”. Terry was really entertained by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so kind”. Mia had meant for him to be really entertained by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so mean”. Mia had meant for him to be really entertained by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so kind”. Terry was really offended by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so mean”. Terry was really offended by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so kind”. Mia had meant for him to be really offended by this remark.

Terry had been laughing whilst telling a story about when he teased his little sister until she cried. Mia said to him, “Youíre so mean”. Mia had meant for him to be really offended by this remark.

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Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was attractive”. Kirk thought that this was a very hilarious remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was disgusting”. Kirk thought that this was a very hilarious remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was attractive”. Dawn had intended for this to be a very hilarious remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was disgusting”. Dawn had intended for this to be a very hilarious remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was attractive”. Kirk thought that this was a very insulting remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was disgusting”. Kirk thought that this was a very insulting remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was attractive”. Dawn had intended for this to be a very insulting remark.

Kirk had just finished eating his dinner, whilst talking with his mouth full. Dawn said to him, “That was disgusting”. Dawn had intended for this to be a very insulting remark.

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John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was brave”. John thought that this was a very witty remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was cowardly”. John thought that this was a very witty remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was brave”. Anna had meant for this to be a very witty remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was cowardly”. Anna had meant for this to be a very witty remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was brave”. John thought that this was a very mean remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was cowardly”. John thought that this was a very mean remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was brave”. Anna had meant for this to be a very mean remark.

John had been scared by a huge spider in the bathroom sink and immediately ran out shouting. Anna said to him, “That was cowardly”. Anna had meant for this to be a very mean remark.

Appendix D

Experiment 7 Materials:

Full set of experimental questions in each condition. Note that for each of the items below, conditions are listed in the order: Self, Familiar Other, and Unfamiliar Other.

1a. Tell me somewhere you would like to go over Christmas and why you would like to go there?

1b. Tell me somewhere your mother/father would like to go over Christmas and why she/he would like to go there?

1c. where do you think Marina/Jack would like to go over Christmas and why you think Marina/John would like to go there?

2a. Tell me something you have to do during the week and something you like to do over the weekends?

2b. Tell me something your mother/father has to do during the week and something she/he likes to do over the weekends?

2c. what do you think Marina/Jack has to do during the week and what do you think she/he would like to do over the weekends?

3a. could you tell me about a dish that you like to eat and whether you can cook it?

3b. could you tell me about a dish your mother/father likes and whether she/he can cook it?

3c. could you tell me about a dish that you think Marina/Jack likes and whether you think she/he can cook it?

4a. Tell me what kind of programs you like to watch on TV and why do you like watching it?

4b. Tell me what kind of programs your mother/father likes to watch on TV and why she/he likes watching it?

4b. Tell me what kind of programs you think Maria/Jack would like to watch on TV and why you think she/he would like watching it.

5a. Tell me one thing you like about living in England and one thing you don’t like about living in England?

5b. Tell me one thing your mother/father likes about living in England and one thing she/he doesn’t like about living in England?

5c. tell me one thing you think Marina/Jack likes about living in England and one thing you think she/he doesn’t like about living in England?

6a. Name a place you would like to visit in England and why would you like to visit there?

6b. Name a place your mother/father would like to visit in England and why she/he would like to visit there?

6c. Name a place you think Marina/Jack would like to visit in England and why you think they would like to visit there?

7a. Tell me what you like to buy when you go shopping and why you like to buy it?

7b. Tell me what your mother/father likes to buy when she/he goes shopping and why she/he likes to buy it?

7c. tell me what do you think Marina/Jack would like to buy when she/he goes shopping and why you think she/he would like to buy it?

8a. Tell me something you like to do in your spare time, like a sport or an activity, then describe some of the rules of this sport/activity?

8b. Tell me something your mother/father likes to do in her/his spare time, like a sport or an activity, then describe some of the rules of this sport/activity?

8c. tell me something you think Marina/Jack likes to do in her/his spare time, like a sport or an activity, then describe some of the rules of this sport/activity?

9a. Tell me who is your favourite celebrity and why you like him/her?

9b. Tell me who is your mother/father's favourite celebrity and why she/he likes him/her?

9c. Tell me who you think is Marina's/Jack's favourite celebrity and why you think Marina/Jack would like him/her?