Examining the neural, behavioural, and social responses associated with affective self-referential processing in adults and children

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Anna Hudson was the sole author of Chapters 1 and 5, which were written under the supervision of Dr. Roxane Itier and Dr. Heather Henderson and were not written for publication.

In addition to Chapters 1 and 5, this thesis consists of three manuscripts (Chapters 2, 3 and 4) written for publication. Exceptions to sole authorship of material are as follows:

Research presented in Chapters 2, 3, and 4:

Dr. Roxane Itier was the primary investigator on the Natural Sciences and Engineering Research Council of Canada (*NSERC Discovery Grant #418431*), Ontario government (*Early Researcher Award, ER11-08-172*), Canada Foundation for Innovation (*CFI, #213322*), and Canada Research Chair (*CRC, #213322)* and Dr. Heather Henderson was the primary investigator on the Sciences and Humanities Research Council of Canada [435-2016-0494] and the Canada Foundation for Innovation and Ontario Research Fund Awards that supported conducting this work.

The research in each of these chapters was conducted at the University of Waterloo by Anna Hudson under the supervision of Dr. Roxane Itier and Dr. Heather Henderson. Anna Hudson, Dr. Roxane Itier and Dr. Heather Henderson contributed to study conceptualization and design. Anna Hudson programmed the experiments and ran the participants. She cleaned the participant data and analysed it with input from Dr. Roxane Itier and Dr. Heather Henderson. Anna Hudson was first author of all manuscripts, to which Dr. Roxane Itier and Dr. Heather Henderson contributed intellectual input and editing. Chapter 3 was also supported by Emma Green and McLennon Wilson, who helped with data collection and manuscript editing.

The research in Chapter 2 has been submitted for review to *Brain and Cognition* (ref: BRCG-D-22-00118) and Chapter 3 is a published manuscript (see citation below).

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Abstract

Information processing biases favouring self- compared to other-referential and positive compared to negative stimuli are theorized to be healthy, adaptive outcomes of well-regulated attention. Within the lab, self-referential information modulates neural encoding of affective trait adjectives and neutral faces as indicated by enhanced event related potential (ERP) amplitudes (i.e., the late positive potential; LPP). Enhanced LPP amplitudes during stimulus encoding in a self- compared to other-relevant context is thought to reflect increased sustained attention following motivationally relevant information, which also supports memory performance for information presented in a self- compared to other-referential context (hereafter the self-referential bias). Similarly, positive compared to negative trait-adjectives are also preferentially attended to (as reflected by enhanced LPP amplitudes) and consequently better remembered (hereafter the positivity-bias), although these findings are mixed. Across the three studies presented in this thesis, I examined how the self-referential and positivity biases modulate the encoding and memory for social information in adults and children, focusing on the LPP waveform and incidental memory performance. I also examined how individual differences in children's biases are related to temperament and observed conversational styles with unfamiliar peers.

In Study 1, I examined how self- compared to other-referential positive and negative cues from social contextual primes (e.g., "She thinks you/he are/is amazing") modulated adult LPP amplitudes and subjective ratings towards neutral faces. For the first time, I also examined incidental memory for the trait adjectives embedded within the primes, rather than the stimuli which undergo a subjective rating (i.e., the faces), as is done in the majority of past studies. Replicating previous findings, neutral faces following self- compared to other-referential primes were rated as more arousing and elicited stronger feelings (i.e., more positive and more negative). Subjective arousal was also greater for neutral faces following negative relative to positive social primes, particularly when the primes were about oneself rather than someone else. Faces primed by a self-referential social statement also elicited larger LPP amplitudes relative to faces primed by other-referential statements. However, there was no effect of valence, nor an interaction between referential and valence cues on ERPs. These results were interpreted to reflect heightened attention following a self-referential cue regardless of valence. It was therefore unsurprising that memory was improved for trait adjectives that were presented in a self- compared to an other-referential contextual prime. This novel finding was interpreted to reflect prioritized processing of incidentally encoded self-relevant information which does not necessarily undergo a task-related behavioural response.

While the self-referential and positivity biases have been explored extensively within adults, it remains unclear how children encode self- compared to other-referential trait adjectives across the LPP. In Study 2, I examined 9–12-year-old children's LPP responses during the encoding of trait adjectives in

a Self-Referential Encoding Task (the SRET), as well as their incidental memory for those trait adjectives. The SRET requires participants to behaviourally endorse or reject positive and negative trait adjectives as they relate to the self (self-referential) or someone else (other-referential). Incidental memory is then tested to determine how referent and valence cues modulate memory performance. Results revealed enhanced LPP amplitudes for trait adjectives presented in a self- compared to an other-referential condition; however, there was no effect of valence, nor an interaction, across the LPP. This is the first study to examine child ERP responses to self- compared to other-referential cues, and these results suggest that 9-12 year old's encode self-referential cues in a similar pattern across the LPP relative to adults. Interestingly, there was no clear effect of referent or valence cues on children's memory, with memory performance being dependent on the block order in which referent cues were presented. This pattern across memory is discussed in the framework of different consolidation mechanisms for valence cues depending on whether the information is self- or other-relevant.

The final goal of my thesis was to examine whether individual differences in children's self-referential and positivity biases found in controlled lab settings (i.e., from the SRET) are related to children's temperament (surgency, effortful control) and in vivo social behaviours. I developed a novel coding scheme to capture indices of the self-referential bias and the positivity-bias based on the content of children's conversations with an unfamiliar peer. Results revealed that higher effortful control was associated with a larger memory bias for positive relative to negative trait adjectives, supporting the role of control processes in children's memory performance for positive information. While no other hypothesized associations were supported, this study sets the stage for future work to explore the translational implications of individual differences in self-referential and valence-based biases for social development.

The results of these three studies are discussed in terms of how the self-referential and positivity biases influence social development. We now know that the self-referential bias develops early and is expressed similarly across the LPP between adults and 9-12-year-old children. This enhanced attention improves subsequent memory for self-referential information, although memory is influenced by task parameters. I did not find any support for a positivity bias across neural encoding and memory, which questions its reliability and suggests this bias is task dependent. Despite the relative inconsistency of the positivity-bias in memory, children's Effortful Control was associated with individual differences in one's positive relative to negative memory performance. Together, these findings suggest that self-referential cues increase sustained attention at encoding which may have implications for social development in general, whereas valence processing modulates attention and behaviour differently depending on the situation in which they are experienced.

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Dedication

This dissertation is dedicated to my family. Through hell and back we have stood strong and have supported each other through it all. I would not have been here if it weren't for you and your unconditional love and support. Thank you.

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List of Abbreviations

ERP(s)	Event Related Potential(s)
EC	Effortful Control
PFC	Prefrontal Cortex
ACC	Anterior Cingulate Cortex
(e)(l)LPP	(early) (late) Late Positive Potential
MUS	Mass Univariate Statistics
EPN	Early Posterior Negativity
FMUT	Factorial Mass Univariate ERP Toolbox
GTKY	Get to Know You
FCM	Fronto-central Midline
D-prime (*d*')	Memory Sensitivity
SPSS	Statistical Package for the Social Sciences

Chapter 1: General Introduction

This thesis investigates how information that is related to the self is better attended to and consequently better remembered than information that is related to others. This attentional bias, known as the self-referential bias, is adaptive for social development by providing a basis for understanding others through first understanding oneself (Hobson et al., 2006; Hughes & Devine, 2015; Hughes & Leekam, 2004; Mahy et al., 2014). Neurotypical individuals also demonstrate an attentional bias towards positive relative to negative social cues, thought to support the adaptive development of a positive self- and worldview (Fiske & Taylor, 1991; Maddi, 1996; Rogers et al., 1977). The development of these biases may be related to one's in-born traits related to reactivity and control, based on behavioural and neural overlap of these biases and one's temperament (Posner & Rothbart, 2007; Rothbart & Rueda, 2005). However, there remains significant gaps in our understanding of the scope of these biases and whether individual differences in their magnitude may relate to everyday social behaviour. The overarching goals of my dissertation are to understand how the self-referential and positivity biases modulate face processing in adults, trait-adjective processing in children, and how individual differences in these biases relate to temperament and observable social behaviours.

The literature examining how self-referential and valence-based cues modulate attention has used a variety of paradigms and stimuli (i.e., verbal, spatial, emotional, facial; for review see Northoff et al., 2006), an approach that is continued across the three studies presented in this thesis. My first goal was to determine the extent to which self-referential cues modulate attention during the encoding of neutral faces across behavioural and event related potentials (ERPs) in adults, and how these changes in attention influence memory for contextual information (Chapter 2). My second goal was to build on my previous work in adults (Hudson et al., 2020) to examine, for the first time, how children encode self-referential and valence-based cues across ERPs during trait-adjective processing. I also examined how attention at encoding influenced children's memory for these trait-adjectives (Chapter 3). My final goal was to examine whether individual differences in children's attentional biases during lab tasks are associated with children's temperament and conversational styles during a live interaction with an unfamiliar peer (Chapter 4). The findings from my three studies are discussed in terms of a broader framework describing the impact of self-referential and valence cues on sustained attention and memory during social information processing.

1.1 Sustained Attention: The Self-Referential and Positivity Biases during Encoding.

In neurotypical adults, the self-referential and positivity biases are captured as enhanced ERP amplitudes during the encoding of stimuli presented in a self- compared to a non-self-referential context, and positive relative to negative context, respectively (Auerbach et al., 2016; Hudson et al., 2020; Shestyuk & Deldin, 2010). These enhanced ERP amplitudes are interpreted to reflect sustained attention dedicated to the processing of these stimuli during encoding (neural activation in Figure 1; Auerbach et al., 2016; Hudson et al., 2020; Shestyuk & Deldin, 2010). While 'sustained attention' is defined in numerous ways within the extant literature (Esterman & Rothlein, 2019), I conceptualise sustained attention as an energizing effect that facilitates the detection and processing of important environmental cues. In this section, I describe the ERP modulations of the self-referential and positivity biases in terms of their impact on sustained attention during stimulus encoding.

ERPs measured through electroencephalography provide a precise temporal measure with millisecond resolution for tracking when information is first distinguished in the brain (Luck & Kappenman, 2012). Previous work has demonstrated that self- compared to other-referential visual (including verbal) cues enhance the late positive potential waveform (LPP), which is measured between 400ms and 1200ms post-stimulus onset at fronto-central sites in neurotypical adults (Hudson et al., 2020; McCrackin & Itier, 2018; Pereira et al., 2021). Given the broad temporal span of the LPP, researchers have separated the waveform into the early (eLPP) and late (lLPP) components, thought to reflect different aspects of attention modulations. The eLPP is specifically associated with arousal-based approach motivation and sustained information processing upon encoding (between 400-600ms; Gable & Harmon-Jones, 2013; Hajcak et al., 2010; Naumann et al., 1992; Schupp et al., 2000) while the lLPP is associated with interpretation and memory consolidation of motivationally relevant stimuli (between 600-1200ms; Hajcak et al., 2010; Ruchkin et al., 1988). In the Self Referential Encoding Task (Rogers et al., 1977), whereby participants endorse positive (e.g., smart) and negative (e.g., unkind) trait adjectives presented in self- ('does this word describe you?') and other- ('does this word describe [other character]') referential contexts, healthy adults display enhanced eLPP and lLPP amplitudes in response to trait adjectives encoded as self- compared to other-relevant, regardless of valence (Herbert et al., 2011; Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010). This pattern of sustained attention indexed by enhanced ERP amplitudes has also been demonstrated when adults encode neutral faces primed by self- ('he thinks *you* are ….') compared to other- ('he thinks *she* is…') referential social statements (Klein et al., 2015; McCrackin & Itier, 2018; Wieser & Brosch, 2012). Interestingly, this effect for neutral faces was captured not only on the LPP, but also the early posterior negativity (EPN) waveform, also regardless of valence (Klein et al., 2015; Wieser & Brosch, 2012). The EPN is measured across posterior electrodes between 200-400ms and is enhanced (more negative) to emotional stimuli (Schupp et al, 2003; Schacht & Sommer, 2009; Rellecke et al., 2013). While this finding across the EPN needs to be replicated to confirm its reliability, these converging results suggest that ERPs –in particular, the LPP – provide a reliable electrocortical index of the self-referential bias (Figure 1), reflecting increased sustained attention for various stimuli following self- compared to other-referential cues.

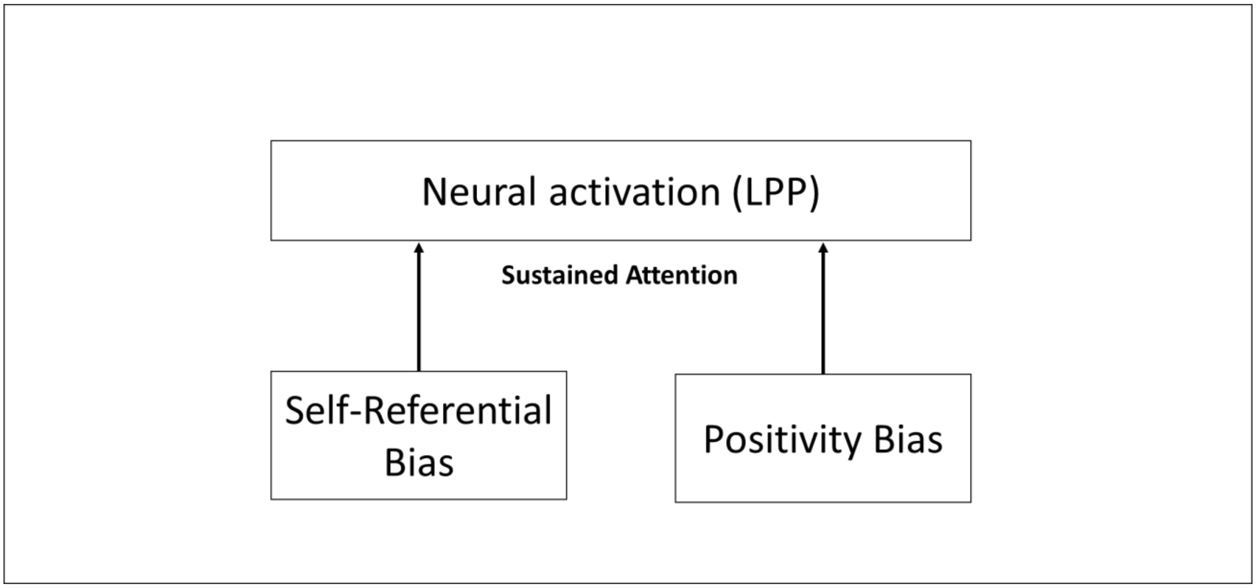

Figure 1. The self-referential and positivity biases.

The self-referential and positivity biases have been demonstrated in adults across ERPs using a variety of lab-based paradigms. Typically, ERP amplitudes are enhanced to self- (compared to other-) referential and positive (compared to negative) stimuli presented within a Self-Referential Encoding Task (SRET). The enhanced ERP amplitudes are thought to reflect sustained attention following self-referential and positive cues. These lab results are reflected as unidirectional black arrows in the present figure.

Similar to the self-referential bias, healthy adults sometimes (but not always) show enhanced LPP amplitudes when encoding positive compared to negative trait adjectives across the SRET, reflecting an electrocortical index of the positivity-bias (Figure 1). However, the bulk of past work examining the positivity-bias across ERPs are limited such that they only present positive and negative trait adjectives in a self-referential condition, without an other-referent condition for comparison (Auerbach et al., 2015; Auerbach et al., 2016; Dainer-Best et al., 2017; Hayden et al., 2014; Prieto et al., 1992; Quevedo et al., 2017; Ramel et al., 2007; for brief review, see Scher et al., 2005). Consequently, past work has identified a *self-positivity* bias in healthy individuals that uniquely favours the encoding of positive self-referential trait adjectives. However, without an other-referent condition for comparison, the “self-positivity” effect may simply be the positivity bias presented in one referent condition (see Chapter 3 for details). Further confusion surrounding the positivity-bias is seen in the timing of the effect across ERPs and is suggested to be task or stimulus specific (for review, see Kauschke et al., 2019). Moreover, there is confusion related to the effect of valence cues on the encoding of neutral faces, with one recent study finding evidence for the self-positivity bias across the EPN and the LPP in a paradigm containing both self- and other-referential social statements (McCrackin & Itier., 2018). I explore the role of referent and valence cues on the neural encoding of neutral faces in Chapter 2, as more work is needed to fully elucidate the specifics of the positivity-bias, or self-positivity bias, across ERP encoding of neutral faces.

While both the self-referential and positivity biases are important for our understanding of social development (see Section 1.3), no ERP study has examined valence processing in self- compared to other-referential contexts in children. It is therefore unknown whether, in childhood, valence and referent cues are encoded separately (as in adults) or interact across ERPs, resulting in the self-positivity bias. Such an interaction between referent and valence cues during encoding is possible given the reduced cortical differentiation in referent and valence processing brain areas in preadolescent children relative to adults (see Casey et al., 2019 for review of adolescent brain development), and given a general tendency for children to hold overly positive self-perceptions and outlooks (Crone & Fuligni, 2020). I address this gap in the literature in Chapter 3 by examining child ERPs during the encoding of positive and negative self- and other-referential trait adjectives.

1.2 The Self-Referential and Positivity Bias in Memory.

Throughout this thesis, I explore the processing of self-referential and valence information in the context of sustained attention during encoding (Figure 1) and regulatory control during memory performance (Figure 2). In this framework, self-referential and (potentially) positive information enhance attention at encoding (Section 1.1), allowing for more elaborative processing and consolidation and subsequently improved memory retrieval and recognition for that information. Examining incidental (surprise) free recall (the ability to self-produce items previously encoded) and recognition memory (the ability to identify old, previously observed items in an array) as an outcome following encoding, highlights the depth with which a stimulus has been processed, without the use of memory strategies (i.e., rehearsal; Craik & Lockhart, 1972). Thus, in this context, improved incidental memory for self-referential and positive stimuli are interpreted to reflect an enhanced depth of processing relative to stimuli which are not elaboratively processed upon encoding.

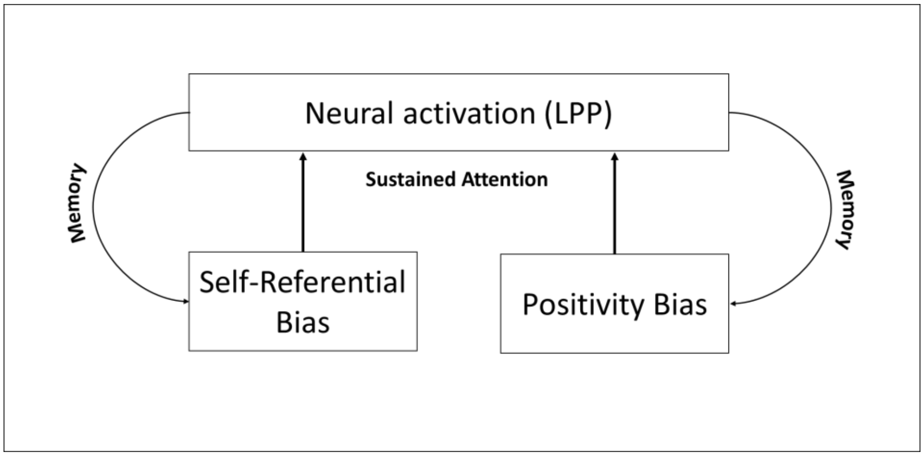

Figure 2. Sustained attention and regulatory control in the self-referential and positivity biases.

The enhanced LPP amplitudes following a self-referential and positive cue are thought to reflect sustained attention during information encoding, which permits improved memory consolidation and eventual retrieval and recognition later on for self-referential and positive information. This memory enhancement is reflected as unidirectional black arrows in the present figure.

The self-referential bias in memory has been robustly demonstrated across various lab-based paradigms. Trait adjectives that are presented in a self- compared to other-referential context ("Does this word describe *you*/[*someone else*]") are more accurately recalled and recognized in adults (for review, see Symons & Johnson, 1997), and typically-developing children (Burrows et al., 2017; Henderson et al., 2009; Ross et al., 2020). Similarly, objects are correctly recognized more frequently when presented alongside an image of a child's own face, rather than the image of another child's face (Andrews et al., 2020; Cunningham et al., 2014; Ross et al., 2020), and when presented in self- compared to other-referential ownership tasks (van den Bos et al., 2010). One recent study with adults reported that self- compared to other-relevant social primes ("He thinks *you/she* is smart/ugly"; McCrackin et al., 2021), improved participant memory for neutral faces presented immediately following the prime. I believe these results reflect the relative consistency of enhanced attention following a self-referential cue at encoding (i.e., the word "you"; one's own face), which in turn improves memory performance for self-referential information (Figure 2). However, in these studies, participants were required to make some sort of subjective judgement (for the faces; 'how positive/negative/aroused did this face make you feel?'; McCrackin et al., 2021; for the objects; "Would you/[someone else] like this object or would you/[someone else] not be very fussed about it?; Cunningham et al., 2014; Ross et al., 2020), or identify who is looking at an object ("Who is looking at the flower?"; Andrews et al., 2020). Thus, it is unclear whether information that does not undergo a task-related behavioural response will still be attended to more and consequently better remembered following a self-referential prime, thereby reflecting improved depth of processing because of a self-referential context alone. I explore this gap in the literature in Chapter 2.

Similar to the mixed effects of cue valence on sustained attention at stimulus encoding (see Section 1.1), the effects of valence on memory are also mixed. One explanation for these mixed results is that task demands modulate attention during the encoding process, which in turn modulates consolidation processes. For example, when responding to trait adjectives, adults display both enhanced sustained attention at encoding and subsequently show improved memory for positive relative to negative trait adjectives (Auerbach et al., 2016; Burrows et al., 2017; Glisky & Marquine, 2009; Shestyuk & Deldin, 2010). However, using different task parameters (i.e., word lists; trial presentation style; number of words), others have not found this memory enhancement (for mixed results see Hudson et al., 2020; for review see Kauschke et al., 2019). Once again, these tasks required participants to make explicit behaviour judgements about the positive and negative trait adjectives presented in a self- or other-referential condition. These design and stimulus differences across studies might make the positivity-bias difficult to capture across memory indices. To remove the potentially confounding role of task-related behavioural responses on memory performance for valence cues, in Chapter 2 I examine incidental memory for positive and negative trait adjectives in a paradigm that does not ask participants to explicitly judge or sort those adjectives.

1.3 Individual Differences impacting Sustained Attention and Regulatory Processes: Surgency and Effortful Control.

The relative strength of the sustained attention and memory consolidation processes for self-referential and positive information may be related to individual differences in reactive and regulatory (e.g., control) attributes of temperament (Figure 3). Temperament, described as biologically-based individual differences in emotional and behavioural reactivity and self-regulation, is present from birth and relatively stable across the life course (Rothbart & Posner, 2004). In infancy, individual differences in reactivity can colloquially be seen as the observable differences between “easy” and “fussy” infants. Highly reactive infants respond quickly, intensely, and negatively to changes in their internal and external environments, whereas less reactive infants have a higher threshold for unease in response to these changes. Early in development, infants are entirely dependent on parents to regulate them and their emotions (i.e., via rocking, soothing) but gradually infants learn to self-regulate through basic attention shifting and self-soothing behaviours (i.e., finding distractions; Henderson & Mundy, 2013; Kopp, 1982). The observable differences in approach and reactivity and regulatory capacities are captured by individual differences in surgency (approach/reactivity) and effortful control (EC; self-regulation), respectively (see blue bidirectional arrows in Figure 3). Surgency is colloquially seen as extroverted behaviours and describes one's approach and engagement with novelty (Rothbart & Derryberry, 1981; Rothbart & Posner, 2004). The temperamental factor of EC underlies children's tendencies to regulate their initial reactions in support of goal-directed behaviour and is characterized by the inhibition of prepotent emotional and behavioural responses (Kochanska & Knaack, 2003; Rothbart, 2007; Rothbart & Rueda, 2005; Sanson et al., 2004). Higher surgency and EC are independently associated with improved academic achievement, positive peer interactions, self-esteem, and adaptive social and emotional development across the lifespan (Eisenberg, et al., 2006; Pike & Atzaba-Poria, 2003; Rothbart, 2007; for review, see Putnam & Stifter, 2008). For example, 4- to 8-year-old children rated high in EC were also rated as more prosocial, popular, and socially appropriate by teachers (Eisenberg, Spinrad, et al., 2007), and increased EC in adolescence (typically measured as conscientiousness; Jensen-Campbell & Malcolm, 2007) is related to increased ratings of liking by their peers (Jensen-Campbell & Malcolm, 2007; for review see Rothbart & Rueder, 2005). Together, the motivation to approach others (surgency) and the ability to effectively regulate attention in the service of goal-directed actions (EC) contribute to adaptive developmental outcomes, potentially including the development of the self-referential and positivity attentional biases.

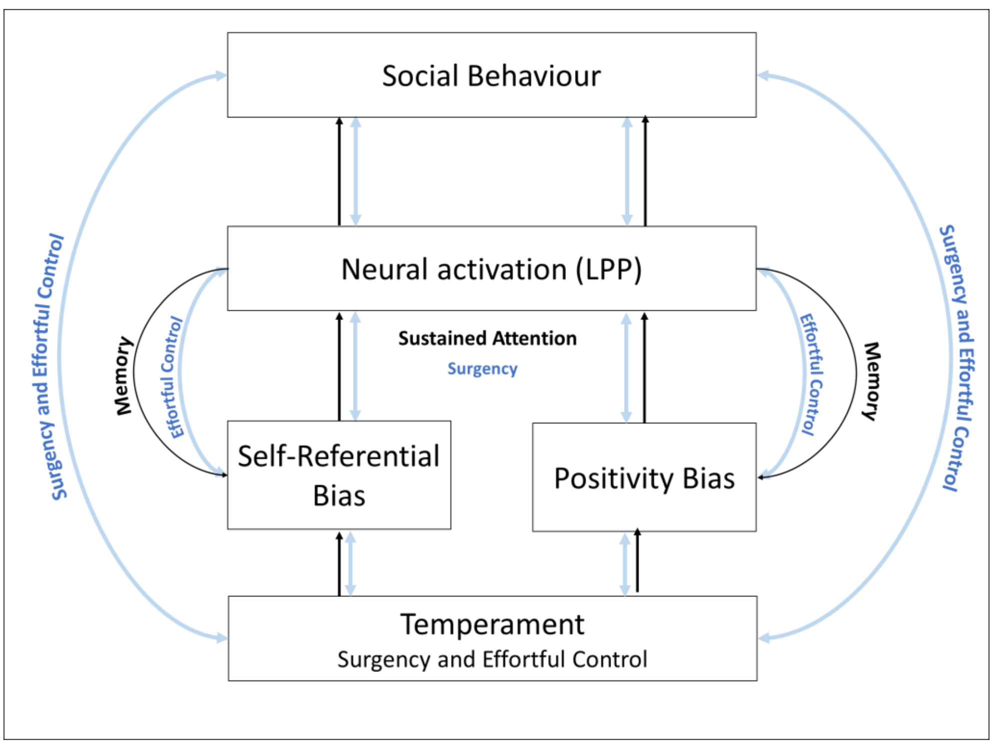

Figure 3. Individual differences in self-referential and positivity biases: Considering temperament

While empirical work highlights the distinctiveness of self-referential and valence processing within the lab (black arrows), these results are thought to reflect one's temperamental surgency and effortful control (blue bi-directional arrows). I propose that surgency and EC guide attention and memory consolidation for self-referential and positive social information. I further propose that surgency and EC, as well as the self-referential and positivity-biases are associated with social behaviour in the lab.

The self-referential and positivity-biases found in the lab are interpreted to support social development and behaviour across the lifespan, but how this occurs is less understood (blue arrows in Figure 3). The self-referential bias is thought to provide the basis for developing social skills and behaviours, including the understanding that others are independent mental agents (Carpendale & Lewis, 2004; Hughes & Devine, 2015; Hughes & Leekam, 2004; Mahy et al., 2014). This understanding that others have unique thoughts and feelings is evident beginning as early as six months of age (Eisenberg et al., 2015; Harter, 2006), and is of particular importance for social development (Carrington & Bailey, 2009). The complimentary positivity-bias is thought to reflect a protective mechanism which also develops in early childhood. Individuals are constantly bombarded with both positive and negative social feedback and information as they experience different social interactions. While both are critical for shaping social competence through teaching and enforcing social norms, ruminating on negative social information has detrimental consequences on one's mental health (Hsu et al., 2021; Nejad et al., 2013). The positivity bias in the context of self-referential processing is specifically associated with the maintenance of a positive affect (Grafton et al., 2012; Troller-Renfree et al., 2015; Derryberry & Reed, 1994; Troller-Renfree et al., 2015; Frewen, Dozois, Joanisse, & Neufeld, 2008), and reduced internalizing symptoms (McCabe & Gotlib, 1995; Frewen et al., 2008). Thus, the self-referential and positivity-biases are both normative and adaptive in supporting social development through modulating attention and memory for social information (Figure 3). However, while the role of these biases for the development of social behaviours are assumed within the extant literature, no work has directly examined these associations.

Bringing these disparate literatures together, I propose that surgency maps onto the attentional differences elicited by a self- compared to other-referential cue during encoding. In contrast, since EC redirects and refocuses attention (Graziano & Eisenberg, 2006; Hooker & Knight, 2006; Jensen-Campbell et al., 2002; Leith & Baumeister, 1996; Mayes, 2000; Rothbart & Rueda, 2005; Rubin et al., 2011), I propose that the self-regulatory skills associated with EC (cognitive flexibility, emotion regulation, memory consolidation; Hooker & Knight, 2006; Leith & Baumeister, 1996; Mayes, 2000), map onto elaborative processing and enhanced memory for positive rather than negative social information. EC is specifically thought to contribute to the positivity-bias to promote an active shift in attention away from negative social cues, reducing the likelihood that negative information becomes consolidated into long term memory (Dolcos & Denkova, 2014; Watson et al., 2007). In Chapter 4, I examine the associations between individual differences in children's temperament and their attentional biases captured in the lab, and how both relate to children's conversational styles during live social interactions.

1.4 Summary of thesis objectives.

As reviewed above, the self-referential and positivity biases are crucial for adaptive social development. However, there is still much that we do not know about (1) attention to and memory for contextual self-referential cues; (2) the development of the self-referential and positivity biases in children; or (3) the associations between temperament, social cognitive biases, and social behaviour. I therefore present three studies to fill these gaps within the literature.

To begin, in Chapter 2, I examined how self- compared to other-referential social statements modulate the neural encoding of neutral faces in adults, and how these statements modulate subjective feelings and arousal towards those neutral faces. I also examined how the increased attention following a self- compared to other-referential prime modulates incidental memory for trait adjectives embedded within the contextual social statements. I predicted that, compared to an other-referential contextual prime, a self-referential prime would result in amplified subjective arousal and valence ratings in reporting how the faces made participants feel (replicating previous work, e.g., McCrackin et al., 2021; McCrackin & Itier, 2018; Schwarz et al., 2013; Wieser et al., 2014). Based on previous studies (e.g., McCrackin & Itier, 2018; Wieser et al., 2014), I also predicted that the self- compared to other-referential contextual primes would result in larger EPN and LPP amplitudes during the encoding of subsequent neutral faces. However, given the mixed effects of valence across ERPs, no valence effects or interactions were predicted. The novel prediction of this study was that participants would show improved memory for trait adjectives embedded within self- compared to other-referential contextual primes, but it was unclear whether I would find improved memory for positive relative to negative trait adjectives.

Next, in Chapter 3, I examined the neural encoding across ERPs as children endorsed (responded Yes/No to) positive and negative trait adjectives presented in self- and other-referential contexts. This is the first ERP study to directly examine how children encode positive and negative trait adjectives as they relate to oneself and to another individual. I also examined how self- and other-referential cues influence incidental memory for the trait adjectives. I predicted that children would i) endorse more positive than negative trait adjectives in general (replicating Hudson et al., 2020 in adults); ii) display enhanced LPP amplitudes in response to self- compared to other-relevant contexts (replicating Hudson et al., 2020; Pereira et al., 2021 in adults); and iii) display enhanced LPP amplitudes in response to positive relative to negative trait adjectives (replicating Shestyuk & Deldin., 2010 in adults), given children's generally positive outlooks and self-perceptions (Crone & Fuligni., 2020). I also predicted that children would iv) show improved incidental memory for trait adjectives encoded in a self- compared to other-referential context regardless of valence, and for positive compared to negative trait adjectives, regardless of referent (replicating Burrows et al., 2017; Henderson et al., 2009; Ross et al., 2020 in children). Finally, if referent and valence processing are closely integrated in development, I would also expect that children would have particularly enhanced ERPs and memory for self-positive trait adjectives.

Finally, in Chapter 4 I explored how individual differences in temperament (surgency and EC) were related to children's self-referential and positivity biases (from Chapter 3), and how both temperament and biases were related to children's conversational styles during live dyadic social interactions. I predicted that increased surgency would be associated with the self-referential bias across the LPP, given the relations between Surgency and approach motivations. I also predicted that higher EC would be associated with the positivity bias in memory, given the role of EC in regulatory processes. I also predicted that surgency, EC, the self-referential bias, and the positivity bias would be associated with children's conversational styles. This is the first study to explore how the self-referential and positivity biases measured in a controlled lab-based environment are related to temperament and live social behaviours within the same sample of children.

Chapter 2: The impact of referent and valence on neutral face processing and contextual memory.

2.1 Introduction

As reviewed in Chapter 1, self-referential cues modulate attention during the encoding of visual social cues including trait adjectives, objects, and faces (Northoff et al., 2006). Face processing is central to social cognition and its neural networks have been extensively studied (for a recent review, see Grill-Spector et al., 2017). Across both behavioural and neural responses, there is converging evidence that self- compared to other-referential contextual primes modulate perceivers' attention, resulting in larger amplitudes across event related potentials (ERPs) when encoding subsequent neutral faces (McCrackin & Itier, 2018; Wieser & Brosch, 2012). In turn, this difference in attention during encoding improves implicit memory for the neutral faces presented in a self- compared to other-referential context (McCrackin et al., 2021). However, it remains unclear whether the improved attention following a self-referential prime also improves memory for information within the prime itself. Thus, there are two goals of this study: (1) to replicate past work examining self- compared to other-referential primes on the subsequent encoding of neutral faces across ERPs, and (2) to extend past work by examining whether information within the contextual primes themselves is better remembered when the information is about the self compared to another person.

ERPs are neural markers that index the temporal dynamics of information processing. The early posterior negativity (EPN; 200-400ms) and late positive potential (LPP; 400-1200ms) are two waveforms thought to reflect sustained processing and memory consolidation of motivationally relevant stimuli (Hajcak et al., 2010; Naumann et al., 1992; Ruchkin et al., 1988). The EPN, typically recorded across posterior sites, manifests as an increased negativity in response to emotional (particularly negative) relative to neutral stimuli, including faces (Schupp et al, 2003; Schacht & Sommer, 2009; Rellecke et al., 2013; Durston & Itier, 2021; Itier & Neath-Tavares, 2017; Neath & Itier, 2015; Neath-Tavares & Itier, 2016). The LPP, recorded most prominently across fronto-central sites, is also enhanced in response to various emotional relative to neutral stimuli, also including faces (Foti & Hajcak, 2008; Wieser et al., 2014). Importantly, when recorded during the encoding of neutral faces, the EPN and LPP are impacted by the context in which these faces are presented (for reviews, see Wieser et al., 2014; Wieser & Brosch, 2012). For example, when presented following positive, negative, or neutral biographical contextual primes, neutral faces elicit EPN and LPP waveforms that are consistent with viewing positive, negative, or neutral facial expressions, respectively (Abdel Rahman, 2011). These patterns of results suggest that contextual information modulates attention during the encoding of neutral faces, which can be captured across changes in ERP waveforms.

Of particular interest for the present study is the impact of self-referential contextual information on the processing and interpretation of subsequent neutral faces. Previous work has required participants to subjectively rate how positive or negative they felt (hereafter, subjective feelings) and how aroused they felt (hereafter, subjective arousal) following the presentation of a neutral face which was preceded (i.e., primed) by either positive or negative self-referential (e.g. he/she thinks *your* comment is smart/dumb) or other-referential (e.g. he/she thinks *her/his* comment is smart/dumb) evaluative statements (McCrackin et al., 2021; McCrackin & Itier, 2018; Wieser et al., 2014; Wieser & Moscovitch, 2015; Klein et al., 2015; Schwarz et al., 2013). Behaviourally, self-referential (compared to other-referential) contextual primes amplified participants' subjective ratings after viewing neutral faces, with higher ratings of positive affect following positive statements, higher ratings of negative affect following negative statements, and generally increased feelings of arousal (McCrackin et al., 2021; McCrackin & Itier, 2018; Schwarz et al., 2013; Wieser et al., 2014). Across ERPs at encoding, EPN and LPP amplitudes elicited by the same neutral faces were larger when faces were primed by self- compared to other-referential social statements, regardless of valence (Klein et al., 2015; Wieser et al., 2014). These behavioural and ERP findings are thought to reflect increased sustained attention following self- compared to other-referential contextual cues, which modulates both the participants' subjective feelings towards, and the neural encoding of, neutral faces.

The increased sustained attention following self- compared to other-referential contextual primes has been found to improve incidental memory for neutral faces primed by self-referential statements (McCrackin et al., 2021). However, since these faces underwent a subjective rating ("how positive or negative/ aroused the face made you feel?"), it remains unclear whether the attention following a self-referential cue itself is sufficient to improve memory, or if memory is improved only when participants are required to make a subjective rating. That is, it is unclear whether a similar memory enhancement can be seen for self- compared to other-referential contextual information that is not actively engaged with. To examine this, the present study required participants to read aloud social evaluative statements that varied in referent (self/other) and valence (positive/negative, e.g., "He/She thinks you/he/she are/is kind/ugly"), which were followed by the presentation of a neutral face. Participants were then asked to make subjective ratings of how positive or negative, and how aroused (excited/calm) they felt in response to the neutral face. However, incidental memory was tested for the trait adjectives (e.g., "kind") embedded within the social evaluative priming statements, rather than for the subsequent neutral face stimuli. Improved memory for the trait adjectives embedded within self- compared to other-referential social evaluative statements would suggest that self-referential cues improve attention for all stimuli presented afterwards, not just those that are actively engaged with (i.e., the faces; McCrackin et al., 2021).

In contrast to the relatively consistent effects of self-referential contextual primes on sustained attention (measured through ERPs) during the encoding of neutral faces, the effects of valence (positive versus negative) are mixed. Past work has reported enhanced LPP amplitudes to neutral faces following i) negative statements (Klein et al., 2015); ii) positive or negative statements depending on participants' anxiety levels (Weiser & Moscovitch, 2015); or iii) no effects of valence at all (Weiser et al., 2014). One study reported that neutral face processing was impacted by an interaction between the referent and valence of a contextual prime, with self-positive statements increasing amplitudes across the EPN and the early LPP (McCrackin & Itier, 2018). Given these mixed valence effects, replication of these ERP results is necessary.

One potential reason for the inconsistencies in past ERP findings is the use of traditional analysis techniques and statistics. In the traditional approach, interesting time windows at specific electrodes are often chosen based on visual inspection of the group grand-average waveforms. This approach has been shown to greatly increase Type I and Type II errors (Luck & Gaspelin, 2017) by pre-selecting data which looks to be significantly different (Type I), and through reducing large amounts of data to just one mean amplitude value (across a time-window) at selected electrodes (Type II). These issues can be avoided, at least in part, by using mass univariate statistical analyses, which greatly reduce the probability of statistical errors by performing a massive number of hypothesis tests (e.g., ANOVAs) across all time-points and electrodes (reduce Type II) and applying powerful corrections (reduce Type I). These tests can be performed across all electrodes and time-points (whole scalp and epoch, data-driven approach) or within a-priori, hypothesis-driven, specified time-windows and electrodes (Fields & Kuperberg, 2019; Groppe et al., 2011; Luck & Gaspelin, 2017). This approach may identify the temporal effects of self relevance and valence on neutral face processing more reliably and more precisely relative to the traditional analytic approach.

The Current Study

The goals of the present study were (1) to replicate past studies examining how the referent and valence of social evaluative statements impact the encoding of subsequent neutral faces across ERPs (using mass univariate statistics) and participants' subjective evaluations and (2) to test whether memory for the context primes (i.e., trait adjectives embedded in statements) is better under self-referential (e.g., "He/she thinks *you* are kind") compared to other-referential (e.g., "He/she thinks *she/he* is ugly") conditions.

Similar to past studies, it was predicted that self- compared to other-referential contextual primes would amplify the subjective ratings of positivity, negativity, and arousal elicited by the neutral faces (e.g., McCrackin et al., 2021; McCrackin & Itier, 2018; Schwarz et al., 2013; Wieser et al., 2014). Across ERPs, it was hypothesized that neutral faces primed by self- compared to other-referential social statements would result in more positive EPN and LPP amplitudes (Klein et al., 2015; McCrackin & Itier, 2018; Wieser & Moscovitch, 2015). However, based on the past mixed effects of valence across ERP amplitudes, it was predicted that valence effects, or referent by valence interactions (i.e., self-positive; self-negative) would not survive the mass univariate analyses.

I further hypothesized that memory for the contextual primes would be modulated by referent. Specifically, I predicted that memory would be enhanced for trait adjectives embedded within self-referential (vs. other-referential) social evaluative statements. Such a result would suggest that self-referential cues (you vs. he/she) immediately enhance attention and consequently improve memory even when the stimuli do not undergo an explicit task-related evaluation. In addition, if the positivity bias exists, as suggested by the SRET literature (see section 1.2), then it is possible that the positive relative to the negative trait adjectives of the social evaluative statements would also be better remembered.

2.2 Methods

2.2.1 Participants.

The original goal was to collect data from 40 participants to allow strong statistical power (a sample size larger than most studies in this field). However, data collection was interrupted by the ongoing COVID-19 global pandemic. Thus, 30 participants aged 18-24 years (M = 19.67, SD = 1.50; 19 female) were recruited from the University of Waterloo (UW; summary of participant characteristics is presented in Appendix A, table A1). Since depression is known to modulate neural and behavioural responses to social stimuli (Fossati, 2012; Leppänen et al., 2004; Mogg et al., 2006; Speed et al., 2016), participants were required to score below the risk cut-off score of 9 for depression on the Depression Anxiety Stress Scales (DASS; Parkitny & McAuley, 2010) to be included in the study. Further exclusion criteria included a history of neurological or psychiatric disease, brain lesion, regular use of recreational drugs (i.e., cannabis, cocaine, or heroin), or alcohol abuse. All participants understood English as their first language and had normal or corrected-to-normal vision. All demographic data were collected during the UW research participant pool Mass Testing at the beginning of the term. This study was approved by a UW Research Ethics Board.

After EEG pre-processing (described below), 25 participants (mean age = 19.5, SD = 1.54; 15 female) were retained for ERP data analysis, but all participants were included in the behavioural analyses. A power analysis using GPower (version 3.1.9.4; Erdfelder et al., 1996) deemed this sample close to sufficient to detect a small effect size for a within-subjects interaction across ERPs in a 2 referent x 2 valence ANOVA (based on the smallest effect size from McCrackin & Itier, 2018; η_p^2=.073; effect size f = .28) with a power of .8 (Gpower 3.0 $n_{calculation}$ = 28). Participants provided written informed consent at the start of the study and were remunerated with course credit.

2.2.2 Stimuli.

The referent (2; self; other) by valence (2; positive; negative) experimental design was administered using Experiment Builder (version 1.11.0.1316). A total of 20 neutral face identities (10 male; 10 female) were taken from the Chicago Face Database Version 2.0[1] (Ma et al., 2015). Each image was edited to remove any hair that impeded the face or filled the background and were equated for mean pixel intensity (M = .62, SD = .001) and RMS contrast (M = .44, SD = .0006) using lab-made scripts based off the SHINE toolbox (Willenbockel et al., 2010).

Three sentence lists containing 64 social evaluative statements (32 positive; 32 negative) were created from a lexical database that included normative ratings of valence (from 1=very negative to 9=very positive), arousal and dominance (Warriner et al., 2013). Half of the selected adjectives were categorized as positive (valence ratings greater than 7), and the other half were categorized as negative (valence ratings less than 3). The three word lists were statistically equivalent in terms of valence for positive, F(2,93)=.23, p = .795, and negative trait adjectives, F(2,93)= .24, p = .788, arousal, F(3,191) = .67, p = .511, dominance, F(3,191) = .22, p =.806, and average word length, F(3, 191) = .04, p = .959. Averaged across all word lists, positive words were longer than negative words by an average of .57 characters, t(190) = 2.87 (see Appendix B, Table B1 for word list descriptives). Two lists were used in the first two experimental trial blocks, with the referent of the statement counterbalanced across participants. The third list provided the distractors in the recognition task (described below). Each social evaluative statement was either self- or other-relevant and paired with a positive or negative trait adjective (ex. "He thinks *you*/*she* are/is *kind*/*stupid*"; see Appendix B, Table B2 for the three lists). The gender of the

[1] Female identities: CFD-WF-005-010-N, CFD-WF-009-001-N, CFD-WF-011-002-N, CFD-WF-022-017-N, CFD-WF-024-003-N, CFD-WF-025-019-N, CFD-WF-027-003-N, CFD-WF-029-002-N, CFD-WF-034-006-N, CFD-WF-035-024-N.
Male identities: CFD-WM-006-002-N, CFD-WM-009-002-N, CFD-WM-012-001-N, CFD-WM-014-002-N, CFD-WM-016-001-N, CFD-WM-020-001, CFD-WM-023-001-N, CFD-WM-024-015-N, CFD-WM-029-023-N, CFD-WM-040-022-N

individual holding the evaluative statement was counter-balanced across statements and was always paired with the opposite gender in other-relevant trials to avoid any confusion as to whom the statement was referring to (i.e., He thinks *she* is…; She thinks *he* is….).

2.2.3 Procedure.

Participants were seated 70 cm away from the computer screen with their heads on a chin rest to ensure all participants viewed the screen from the same distance, and to reduce head movement throughout the experiment. During EEG preparation, participants completed five self-report measures[2], followed by a four-minute baseline EEG recording which consisted of two minutes of eyes open whereby participants were told to look at a fixation cross, and two minutes of eyes closed where participants restfully closed their eyes. The baseline EEG data and self-report measures are not included in this study.

Participants received task instructions verbally and read them off the computer screen. Each trial began with a 400-500ms jittered fixation cross, followed by a social evaluative statement (see Figure 4 for a trial example). Participants read this statement aloud to ensure they did not skip through the experiment. They then pressed the spacebar, prompting the onset of a 700ms fixation cross. This timing was to ensure participants had finished moving after speaking aloud to reduce artifacts in the EEG data. A neutral face intended to represent the person who expressed the opinion statement was then presented for 500ms. After a final 500ms fixation cross, participants used the keyboard to report their subjective feelings (“How positive or negative did this face make you feel?”) and arousal (“How calm or excited did this face make you feel?”) on a 7-point Likert scale (1 indicating very negative valence/calm [very low arousal] and 7 indicating very positive valence/excited [very high arousal]). The valence question was always presented first, and the arousal question was always presented second. Again, to reduce eye-movement artifacts, participants were instructed to keep their eyes on the fixation cross until the valence question appeared on the screen. They were told “*since you are going to make a response on the keyboard, it may be tempting to look down right away. This creates noise in our data, so please wait to look down until the question appears on the screen”.* Participants completed 3 practice trials to confirm they understood the instructions.

After two experimental blocks that contained a mix of self- and other-referential trials (64 trials per block, 32 per referent condition, 16 per valence; total of 128 trials), participants completed a distractor task of counting backwards aloud from 50, followed by two surprise memory tasks. By administering the

[2] Questionnaires included the Adult Temperament Questionnaire, the Autism Quotient, the Revised Cheek and Buss Shyness scale, the Social Phobia Inventory, and the State-Trait Inventory for Cognitive and Somatic Anxiety.

memory tasks after the first two blocks, we maintained word numbers in each condition that were comparable to Hudson et al. (2020) and avoided floor effects in memory performance by having too many stimuli for participants to remember. Participants first completed a recall task which required them to write down as many of the adjectives presented at the end of each social evaluative statement as they could remember within a 3-minute time window. Participants then completed a recognition task where each target (old) adjective and a series of distractor (new) adjectives were intermixed on a sheet of paper (128 old, 64 new, 192 adjectives in total). Participants were instructed to circle all the words they recognized from the experiment. The memory tasks were always presented in this order.

Following the memory tasks, participants completed three additional blocks of trials to increase the trial count for the ERP analyses. Importantly, participants were assured there was no additional memory component at the end of these trials. Before starting the additional blocks, participants were told, "*To increase the trial count to improve the reliability of our results, you are going to complete an additional couple of blocks of the task that you were doing before. I can assure you there is no memory tasks after these blocks. This is because you already know about the memory component, and you've already seen the words. Please do not change the way you were completing the task by trying to memorize the sentences, as this may change our results".* The three additional blocks contained the same two target adjective word lists presented in the first two blocks, as well as the distractor word list embedded into newly randomized self- and other-relevant opinion statements (i.e., the adjectives seen as self-relevant in the first two blocks were now seen as other-relevant in the last three blocks) [3].

Once participants completed the experiment, they provided written consent again (due to the deceptive nature of the surprise memory component) and were debriefed.

2.2.4 Electrophysiological Recording.

EEG was continuously recorded at 500 Hz throughout the experimental task using an Acti64Champ system (Brain Vision Solutions Inc.), with electrode impedances kept below 50 kOhms. Custom caps under the extended 10-20 system included 64 recording electrodes with the addition of PO9 and PO10 for greater posterior coverage, with TP9 and TP10 directly recording from the mastoids (we did not record from F1, F2, AF3, and AF4). Electrode Cz was used as the reference site during recording, with all EEG data average-referenced offline.

[3] To ensure there were no differences in behaviour or ERPs across the first two and remaining three blocks of trials, analyses were conducted comparing pre- and post-memory performance. No interactions with order were found, so all subsequent analyses were conducted on the full trial count.

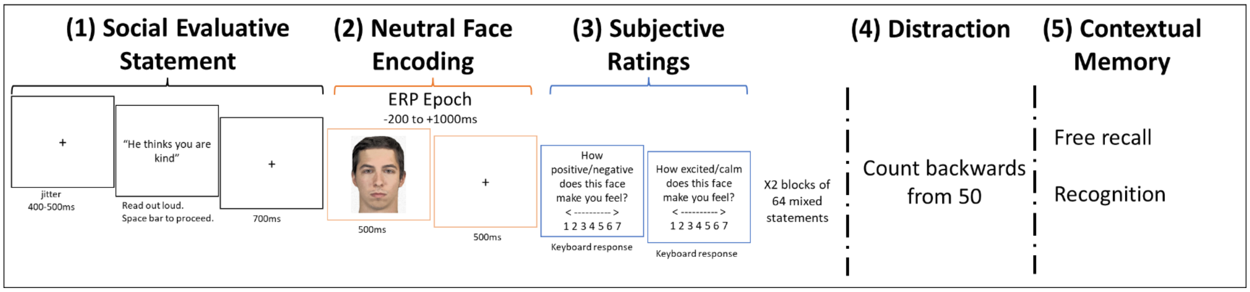

Figure 4. Study 1 trial progression.

Sample trial progression of a self-relevant positive opinion statement. The gender of the neutral face was matched to the gender of the individual holding the opinion (He/male; She/female). Participants (1) read aloud the social evaluative statement that was self (…*you*…) or other (…*he/she*…) relevant; then (2) viewed the neutral face of the person expressing the statement; and (3) responded to how positive/negative (subjective feelings) and how excited/calm (subjective arousal) the face made them feel. After two blocks of trials, participants completed a (4) distractor task, followed by (5) memory tasks for the context of the social evaluative statements. Participants then completed an additional 3 blocks (containing the 1-3 progression) to increase trial count for analyses.

2.3 Data Processing and Analyses

2.3.1 Behavioural Measures.

A series of 2 (Referent: self/other) by 2 (Valence: positive/negative) repeated-measures ANOVAs were conducted for each of the following indices:

(i) Subjective Ratings.

Subjective feelings and arousal. After reading each social statement and viewing a neutral face, participants made subjective feeling and arousal ratings, each on a 7-point Likert scale with 1 on the feelings scale indicating very negative feeling and 7 indicating very positive feeling and 1 on the arousal scale indicating calm/very low arousal and 7 indicating excited/very high arousal. These ratings were averaged within each of the four test conditions (self-positive; self-negative; other-positive; other-negative) across all 5 experimental blocks.

(ii) Contextual Memory.

Recall. Incidental recall memory was tested for the content of the social statements after two blocks of the experiment (see Figure 4). Adjectives were considered correctly recalled if the root form of the word was written (e.g., admirable/admire would be accepted for the target word 'admired').

Recognition. Recognition memory was also tested after two blocks of the experiment. Scores were calculated as a count of the number of old adjectives correctly identified during the recognition task.

Memory Sensitivity (*d'*). To account for false alarms, the sensitivity metric *d'* was computed by subtracting the standardized probability of incorrectly recognizing a distractor/new adjective (false alarm) from the standardized probability of correctly recognizing a target/old adjective (hit; Macmillan & Creelman, 2005). This calculation requires non-zero values in both hit and false alarm rates as well as no perfect score of 1 in either hits or false alarms, thus any participants[4] (N = 5) with cells containing a zero were replaced with the corrected value of .0156 from the formula $\frac{0.5}{N}$ (Macmillan & Creelman, 2005) where *N* refers to the total number of targets/distractors in the condition (in each case, *N* = 32).

2.3.2 Event-Related Potential data.

EEG data were pre-processed offline using EEGlab version 13.6.5b (Delorme & Makeig, 2004) and ERPlab version 5.1.1.0 (http://erpinfo.org/erplab) under Matlab 2014b software (Mathworks, Inc., 2014). ERPs were time-locked to the onset of the neutral face. Raw data were segmented into 1200ms long epochs with a 200ms baseline (-200ms; +1000ms). A two-way least-squares FIR filter digitally band-pass filtered each epoch between 0.01 – 30 Hz. Independent component analysis (ICA) was used to identify and remove eye movement artifacts (i.e., eye blinks and saccades only; mean ICA component removed: M = 1.36; SD = .64). Trials that included artifacts greater than ±70 µV were automatically rejected, with further trials manually rejected following visual inspection. After trial rejection, 2 participants were excluded for excessive noise in the data. An additional 3 participants were excluded due to a technical error during data acquisition. The final sample of 25 participants had an average of 55.63 (SD = 13.51) trials per condition[5]. Average waveforms were computed for each participant across each of the four conditions (self-positive; self-negative; other-positive; other-negative) using ERPLAB and were loaded into the Factorial Mass Univariate Test (FMUT; Fields & Kuperberg, 2019) analysis toolbox (classic analyses of the EPN and LPP components were also performed to compare to the literature and to the results of the mass univariate approach–Appendix C).

To follow up on previous research (Klein et al., 2015; McCrackin & Itier, 2018[6]; Wieser et al., 2014), and to avoid potentially missing smaller effects of the ERPs of interest by looking at the entire epoch, a 2

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[4] Three participants correctly rejected all positive distractors, one participant correctly rejected all negative distractors, and one participant correctly rejected all positive and negative distractors. No participant achieved a perfect score of 1 in either hits or false alarms.
[5] Each condition contained statistically equivalent trial counts: self-positive (M = 55.24, SD = 13.75), self-negative (M = 56.24, SD = 13.74), other-positive (M=55.8, SD = 13.41), other-negative (M=55.24, SD = 13.10).)
[6] McCrackin and Itier (2018) examined the average waveform across seven, 100ms time-windows, beginning at 50ms, and ending at 750ms. Based on visual inspection of the grand average, they averaged the signal across various

(referent) by 2 (valence) ANOVA was conducted across posterior (P9, TP9, PO9, P10, TP10, PO10) and central, centroparietal and frontal (C1, C3, CP1, FC1, CPz, Fz, FCz, C2, C4, CP2, FC2) electrodes[7] across the following a-priori selected time-windows: 200-400ms (EPN), 400-600ms (early LPP), and 600-1000ms (late LPP). As recommended by the FMUT developers, 100,000 permutations for each data point were used to estimate the null distribution, and permutation-based Cluster Mass technique was applied to correct the familywise error rate (Groppe et al., 2011; Maris & Oostenveld, 2007). This technique clusters data points which are temporally and spatially adjacent to determine whether the effect is true or a false positive. For an effect to be significant, the summed clustered *F*-values must fall within the $1 - \alpha$ portion of the customized null distribution. FMUT clusters data points if they are at same time points and neighboring channels or if they are at the same channel and neighboring time points. The electrode neighborhood distance was .4799 (as calculated by FMUT based on the electrode montage), which specifies the maximal distance between electrodes for clustering purposes.

2.4 Results.

2.4.1 Behavioural Data.

Descriptive statistics for each behavioural measure are presented in Table 1 and results are displayed in Figure 5. Follow up interactions used Bonferroni corrections, with a corrected significance threshold of $p = .008$ (.05/6 comparisons).

(i) Subjective Ratings.

Subjective feelings. There was no main effect of referent, $F(1, 29) = .886$, MSE = .029, $p = .354$, $\eta_p^2 = .030$, but there was a main effect of valence, $F(1, 29) = 111.995$, MSE = .881, $p < .001$, $\eta_p^2 = .794$, such that participants rated neutral faces following positive contextual primes as more positive relative to neutral faces following negative contextual primes. This was qualified by a referent by valence interaction, $F(1, 29) = 33.925$, MSE = .075, $p < .001$, $\eta_p^2 = .539$, with the effect of valence amplified in the self- compared to the other-relevant contextual primes (i.e., participants felt more positive towards

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electrode clusters: left (P9, TP9, PO9) and right (P10, TP10, PO10) occipitotemporal clusters, and left (C1, C3, CP1 and FC1), midline (CPz, Cz and FCz) and right (C2, C4, CP2 and FC2) frontocentral and centroparietal clusters. These electrodes were selected a-priori to be used in the present analysis.

[7] Although the EPN is typically analyzed at posterior sites and the LPP at anterior sites, this study analyzed each component at both sites based on the idea that some of the activity can be seen polarity reversed at opposite sites due to the use of the average reference (Dien, 1998).

faces following self-positive contextual primes and more negative following self-negative contextual primes). Follow up t-tests demonstrated that all conditions were significantly different from one another (all *p*'s < .001).

Subjective arousal. There was a main effect of referent, $F(1, 29) = 26.733$, MSE = .203, $p < .001$, $\eta_p^2 = .480$, with participants feeling more aroused when faces followed self- versus other-relevant contextual primes. There was also a main effect of valence, $F(1, 29) = 8.478$, MSE = .410, $p = .007$, $\eta_p^2 = .226$, such that neutral faces were rated as more arousing when they followed negative versus positive contextual primes. This was qualified by a referent by valence interaction, $F(1, 29) = 6.33$, MSE = .047, $p = .170$, $\eta_p^2 = .184$. Follow up t-tests demonstrated that participants reported the highest arousal for faces following self-negative contextual primes (relative to faces following self-positive, $t(1,29) = 3.07$, $p = .005$, other-positive, $t(1,29) = 5.49$, $p < .001$, and other-negative, $t(1,29) = 6.00$, $p < .001$ contextual primes). Arousal ratings were also higher for faces following self-positive relative to other-positive contextual primes, $t(29) = 3.43$, $p = .002$, and for faces following other-positive relative to other-negative contextual primes, $t(29) = -2.42$, $p = .022$. There was no differences in arousal ratings for faces following self-positive and other-negative contextual primes, $t(29) = .579$, $p = .567$.

(ii) Contextual Memory.

Recall. Recall rate was low overall for the trait adjectives presented in the social evaluative priming statements (<12.8% of total words; mean of 13.3% or 2.4/32 words per condition). There was no effect of referent, $F(1, 29) = 1.383$, MSE = 2.66, $p = .249$, $\eta_p^2 = .046$, valence, $F(1, 29) = .038$, MSE = 1.99, $p = .847$, $\eta_p^2 = .001$, or a referent by valence interaction, $F(1, 29) = .112$, MSE = 3.63, $p = .740$, $\eta_p^2 = .004$.

To account for errors in recall (incorrectly writing words which did not appear during the encoding phase), recall scores were converted to proportions of correctly and incorrectly recalled positive and negative words out of the total positive and negative words written (accurate and inaccurate). The main effect of valence remained insignificant, $t(29) = -1.33$, $p = .194$. Of the participants who recalled words which did not appear during the encoding phase (n = 17) these words were no more likely to be positive (M = .217; SD = .178) than negative (M = .17; SD = .144) in valence, $t(16) = .205$, $p = .410$.

Recognition. There was a main effect of referent, $F(1, 29) = 15.934$, MSE = 12.89, $p < .001$, $\eta_p^2 = .355$, such that participants recognized more adjectives in self- compared to other-relevant social evaluative statements. There was also a main effect of valence in the opposite direction than anticipated, $F(1, 29) = 12.760$, MSE = 8.34, $p = .001$, $\eta_p^2 = .306$, such that participants recognized more negative relative to positive adjectives in the social evaluative statements. There was no referent by valence interaction, $F(1, 29) = .990$, MSE = 7.08, $p = .328$, $\eta_p^2 = .033$.

In their recognition errors (i.e., false positives or identifying distractor words as previously seen), participants were more likely to incorrectly recognize negative (M= 4.10; SD = 2.65) relative to positive (M = 2.57; SD = 2.11) trait adjectives, $t(29) = -4.27$, $p < .001$.

D-Prime. There was a main effect of referent, $F(1,29) = 14.12$, MSE = .131, $p = .001$, $\eta_p^2 = .327$, such that participants were more accurate when recognizing trait adjectives embedded in a self- compared to other-referential statement. There was no effect of valence, $F(1, 29) = 1.886$, MSE = .191, $p = .180$, $\eta_p^2 = .061$, nor a referent by valence interaction, $F(1, 29) = .200$, MSE = .066, $p = .658$, $\eta_p^2 = .007$.

Table 1. Means and standard deviations for each variable of interest and each of the four conditions (self-positive, self-negative, other-positive, other-negative).

		Self		Other	
Task		Mean	(SD)	Mean	SD
Valence ratings	Positive	4.81	(.633)	4.55	(.580)
	Negative	2.70	(.575)	3.03	(.518)
Arousal ratings	Positive	3.72	(1.06)	3.39	(1.03)
	Negative	4.16	(1.05)	3.63	(1.02)
Recall (number of words)	Positive	3.03	(2.20)	2.57	(2.34)
	Negative	2.87	(1.83)	2.63	(1.77)
Recognition (number of correct words)	Positive	14.37	(6.14)	11.27	(5.60)
	Negative	15.77	(6.23)	13.63	(5.38)
Memory sensitivity (*d'*)	Positive	1.28	(.604)	1.01	(.591)
	Negative	1.20	(.631)	.954	(.575)

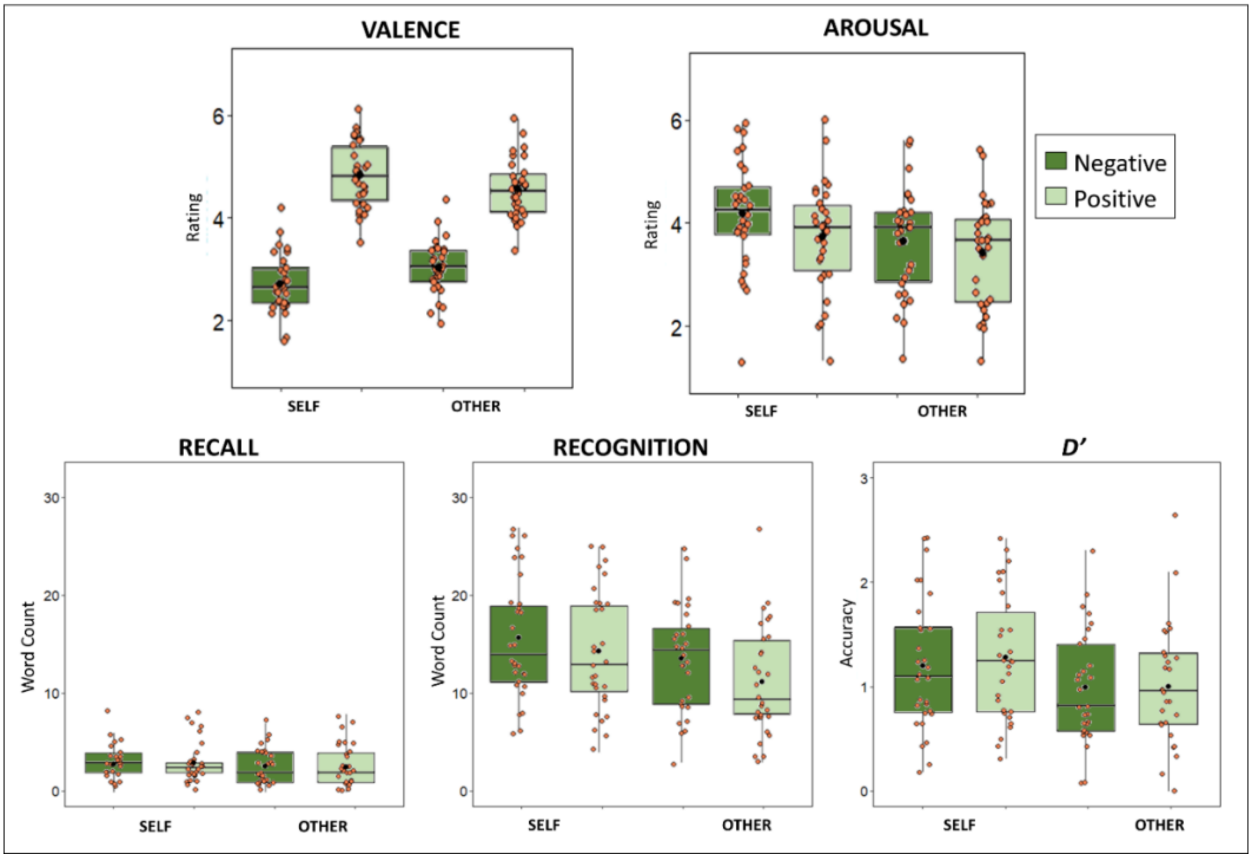

Figure 5. Study 1 behaviour results.

Behavioural results for mean valence and arousal ratings, recall, recognition and *d'* scores. Valence and arousal ranged from a scale of 1-7 (1: very negative/low arousal, to 7: very positive/high arousal with 4 indicating neutral valence and medium arousal). Light green reflects positive prime condition, whereas dark green reflects negative prime conditions. The total number of possible words in each recall and recognition condition is 32. D' of 0 indicated chance level (where hits = false alarms). The black lines within each box represent the median score, the black dots represent the mean, and the tops and bottoms of each box reflect the interquartile range (IQR) between the 25th (Q1) and 75th (Q3) percentile identified in R-studio. The upper and lower limits are reflected as the top and bottom of each whisker, respectively, calculated as Q1-1.5*IQR (minimum) and Q3 + 1.5*IQR (maximum) with outliers seen beyond the whisker range.

2.4.2 Mass-Univariate Analysis of ERP data.

The frontocentral and centroparietal analysis was significant across the 400-600ms time window, encompassing the early LPP (overall cluster p = .012; Figure 6), peaking on electrode C2 at 494ms (F= 27.82). At these time points and electrodes, the amplitude was larger (less negative) for the self- compared to the other-relevant condition. The main effect of valence and the referent by valence interaction were not significant. No cluster was significant across the EPN (200-400ms) or late LPP (600-1000ms) time-windows.

2.4.3 Results Summary

Participants' subjective feelings elicited by neutral faces were amplified following self- compared to other referential social evaluative primes (i.e., more positive valence rating following self-positive primes; more negative following self-negative primes). Additionally, participants felt the most aroused when faces were primed with self-relevant social evaluative statements, especially negative ones.

Across ERPs, self- compared to other-referential social evaluative primes resulted in more positive eLPP (400-600ms) amplitudes at frontocentral and centroparietal sites, when encoding the subsequent neutral faces. There was no effect of valence, or referent by valence interactions across any ERP time windows or electrodes using Mass-Univariate statistics.

Finally, participants were more accurate and recognized significantly more trait adjectives embedded within self- compared to other-referential social evaluative statements. Participants also recognized more negative than positive trait adjectives, but this was not reflected in differences on d' accuracy as they also made more errors for negative adjectives. There was no interaction between referent and valence across any memory indices.

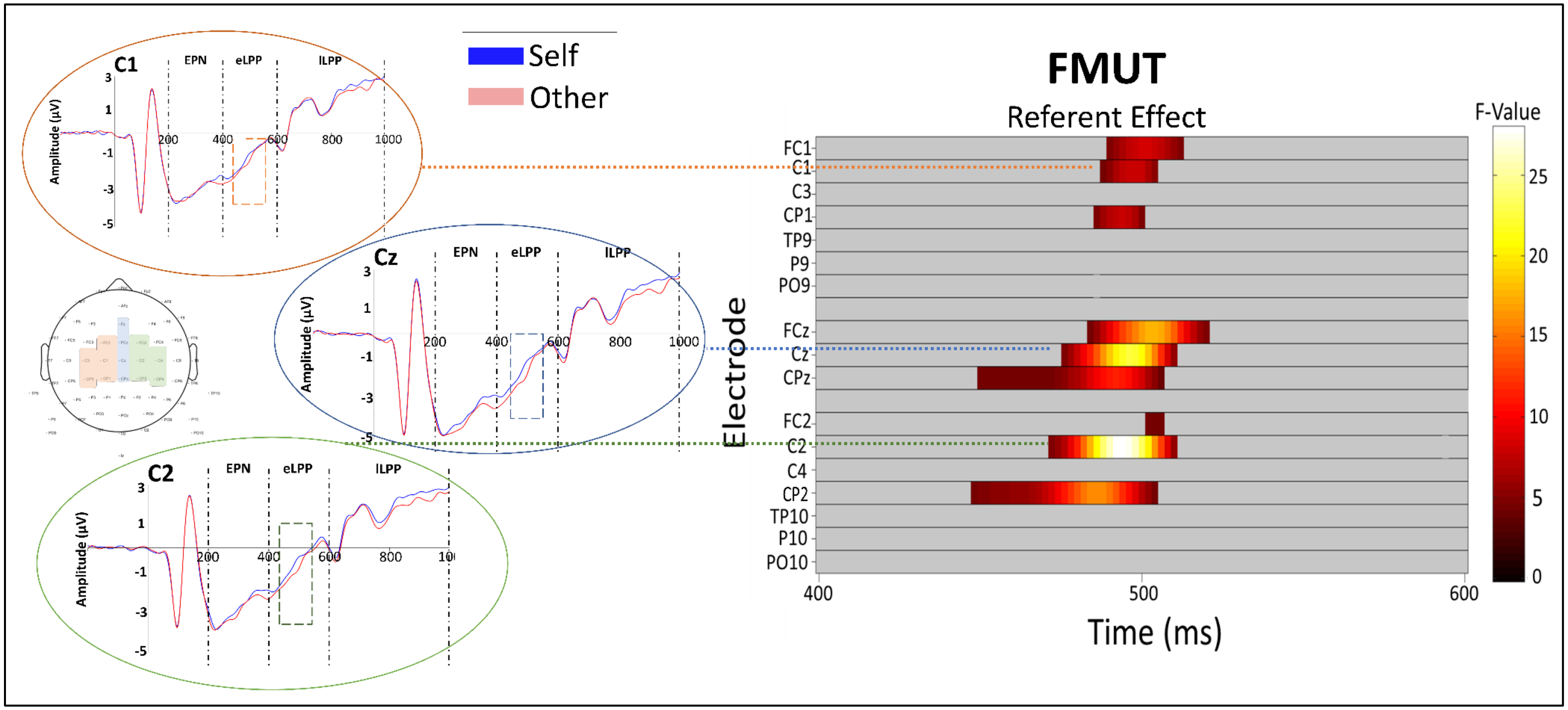

Figure 6. Study 1 FMUT output of ERP effects.

Main effect of referent across frontocentral and centroparietal clusters across the entire 400-1000ms analysis. The time limits of the windows analyzed, encompassing the EPN (200-400ms), eLPP (400-600ms) and lLPP (600-100ms) are labeled on the classic ERP graphs (on the left-hand side) to orient the reader. ERP graphs represent one of the electrodes in the left (C1), center (Cz) and right (C2) clusters (dark blue line representing the Self-relevant condition; dark pink line representing the Other-relevant condition). The dotted lines on the classic ERP graphs represents the period of significance computed by FMUT, with the electrode clusters inputted into FMUT highlighted on an electrode montage map (left). The FMUT output are shown for the 400-600ms time window where the self-referent effect was significant (right-hand side). Significant time points are visible according to the *F*-value coloured scale, with lighter (yellow/white) colours reflecting larger *F*-values. The peak of the self-referent effect was seen at electrode C2 at 494ms.

2.5 Discussion

Previous work has demonstrated that self-referential contextual primes modulate the encoding of neutral faces across ERPs, as well as subjective feelings and arousal ratings to those same neutral faces (McCrackin & Itier, 2018; Schwarz et al., 2013; Wieser & Moscovitch, 2015). It has also been demonstrated that faces presented following self- compared to other-referential contextual primes are better remembered across incidental recognition memory tasks (McCrackin et al., 2021). However, findings are mixed regarding when valence cues modulate the processing of neutral faces across ERPs and whether they interact with self-referential cues. It is also unclear whether the enhanced attention following self- compared to other-referential cues would improve memory for the contextual prime itself. Using ERPs analyzed using mass univariate statistics, the present study examined when positive and negative self- and other-referential contextual primes modulate the encoding of neutral faces, and how memory for the contextual primes was impacted by referent cues.

Consistent with past work, the referent of the statement modulated participants' subjective feelings and subjective arousal towards the neutral faces. Specifically, statements about themselves (vs. another person) resulted in participants feeling particularly positive or negative towards neutral faces which were primed by positive and negative statements, respectively. Participants also reported feeling the most aroused to neutral faces primed with negative statements, particularly when they were about themselves relative to another person. These subjective feelings replicate previous work with healthy adults (McCrackin & Itier, 2018; McCrackin et al., 2021; Schwarz et al., 2013; Wieser et al., 2014), although the specific arousal enhancement for negative-self relevant social statements is novel. These subjective ratings support the view that individuals are particularly attuned to social evaluative information pertaining to themselves (Cunningham & Turk, 2017; Humphreys & Sui, 2016) and provide a behavioural metric demonstrating that self-referential primes modulate attention and feelings towards subsequently presented neutral faces.

The referent of the social evaluative statement also modulated participants' neural responses when encoding the neutral faces. Specifically, eLPP amplitudes between 448-530ms were larger when encoding neutral faces primed by self- compared to other-referential social statements. This result replicates past work using the traditional ERP analysis technique (McCrackin & Itier, 2018; Weiser et al., 2014), supporting the robustness of the effect of self-referential primes on LPP amplitudes when encoding neutral faces. This effect is interpreted as reflecting enhanced sustained attention for stimuli following self- compared to other-referential primes.

As expected, there was no evidence of valence modulations across ERPs, either on their own or in combination with referent effects, when using mass univariate statistics. Currently, McCrackin and Itier (2018) remains the only study using this paradigm to identify enhanced EPN and LPP amplitudes for neutral faces encoded following self-positive statements specifically. Importantly, the present study controlled for arousal when selecting positive and negative trait adjectives, while McCrackin and Itier (2018) selected self-positive adjectives that were previously validated as more arousing than the self- or other-negative adjectives (McCrackin & Itier, 2018). This is important, as the LPP is modulated by arousal (Hajcak et al., 2010); consequently, it is possible that McCrackin and Itier (2018) observed these valence effects on the LPP simply because their positive adjectives were more arousing than their negative ones. It is also possible that the self-positivity effects were observed in their study due to the relatively large sample size (56 participants) and/or because of the relatively large number of trials (i.e., 96 trials/condition). Importantly, they did analyze their data using the classic ERP approach. When analysing the current ERP data using the classic analysis approach (see Appendix C), a small effect of valence at fronto-central sites was found such that amplitudes for neutral faces encoded following negative statements were enhanced relative to positive statements (regardless of referent) between 600-800ms. Wieser and colleagues (2014) also found increased amplitudes for faces following negative statements over the parietal EPN (220-300ms), although this effect was much earlier than that of the present study and presented with a different topography. While increased neural responding to negative information is typical in depressed populations (i.e., Auerbach et al., 2015, 2016; Shestyuk & Deldin, 2010), the findings from this study and from Wieser and colleagues (2014) may suggest that neutral faces in the presence of negative information may undergo some specialized processing in healthy individuals, possibly reflecting source monitoring or emotional reappraisal mechanisms. Since this effect did not survive the mass univariate analysis approach, it is likely that valence effects across ERPs in this paradigm are either spurious or are simply small and would require larger sample size and trial number to detect. Indeed, the present study was underpowered to capture small effect sizes. Future work using mass univariate statistics with large numbers of trials and large sample sizes are necessary to fully elucidate valence modulations on LPP during the encoding of neutral faces primed by valenced sentences.

As expected, the incidental memory for the contextual primes was improved for self- compared to other-referential social evaluative statements. While recall rates were generally low (on average roughly 13% of words per condition), potentially meaning that participants were given too many adjectives to remember, participants did show better recognition and accuracy for adjectives embedded within self- compared to other-referential contexts. This finding is novel but echoes similar results in other lines of research. For instance, self-referential cues have been shown to improve incidental memory for isolated trait adjectives that participants endorsed relative to the self compared to another person (Burrows et al., 2017; Henderson et al., 2009; Hudson et al., 2020; Pereira et al., 2021; Symons & Johnson, 1997). It has also been demonstrated that source memory for stimuli encoded in a self compared to other-referent condition (i.e., "Is this an object you/[someone else] would buy in the next year?"; Serbun et al., 2011; "Does this work describe you/[someone else]"; Turk et al., 2008) is improved for the items encoded in the self-referential condition (i.e., at test: "was this [object] presented in a self- or other-referent condition?"; Serbun et al., 2011; i.e., "did this word appear above or below the referent cue?"; Turk et al., 2008). In all these studies, memory was tested for the stimuli that participants had to engage with directly (i.e., the faces, after which they rated their feelings; the adjectives that they had to endorse; the objects they had to sort). The present study extends these results by demonstrating that trait adjectives embedded within a self- compared to other-referential contextual prime, which are not rated or sorted, are also better remembered. This result suggests that self-referential cues (here, the use of "you" or "yours") enhances attention for all subsequently presented stimuli, and not just the stimuli that undergo an explicit subjective evaluation (i.e., the faces).

One potential explanation for this improved attention to and memory for self-relevant information is the change in arousal for the adjectives upon their placement beside the self-referential cues. Indeed, because adjectives were counterbalanced across the self and other relevant conditions across participants, the adjectives themselves cannot account for the self-relevant effect. However, participants' arousal ratings were increased for neutral faces following self-relevant compared to other-relevant conditions, suggesting a potential link between increased arousal of adjectives presented in self-relevant conditions and their increased recognition accuracy. Support for this general arousal idea also comes from the observation of a graded pattern of arousal ratings (though partially significant) across the four conditions (self-negative mean = 4.16; self-positive mean =3.72; other-negative mean = 3.63; other-positive mean=3.39). Since the trait adjectives in the present study were pre-selected so that they did not differ significantly in arousal between negative and positive conditions, the arousal ratings elicited by the neutral faces were modulated by the placement of these adjectives in the context of self- compared to other-referential social evaluative statements. Interestingly, the pattern of recognition for the trait adjectives also follows this graded pattern (though non-significant), such that participants recognized more self-negative words, followed by self-positive, other-negative, and other-positive words. While these memory differences were not statistically significant, this pattern of results may suggest that referent and valence cues presented as social evaluative statements modulate arousal which in turn improves attention and subsequent recognition memory. Future work could test this arousal idea by comparing physiological changes in arousal (i.e., galvanic skin response; Shi et al., 2007) and ERP responses to trait adjectives when presented in isolation and when embedded within self- and other-referential social evaluative statements, both at encoding and during recognition tasks.

The present study contributes to a line of research demonstrating the salience of self-referential information within social information processing. Specifically, self-referential cues enhanced attention, which was captured across the LPP during encoding, amplified behaviour ratings, and improved memory for contextual information. These results suggests that self-referential cues improve attention for all stimuli presented in a self- compared to other-referential context, not just stimuli that are explicitly engaged with (i.e., the faces; McCrackin et al., 2021; the trait adjectives in SRET paradigms; Symons & Johnson, 1997).

The impact of self-referential and valence primes on ERP indicators of attention has primarily been explored in adults and has yet to be explored thoroughly in children. Behaviourally, children show improved memory for items presented as self- compared to other-referential, and for positive relative to negative isolated trait adjectives. However, it is unclear whether children encode stimuli that are primed by referent (self/other) and valence (positive/negative) cues in a similar way to adults. Thus, Chapter 3 examines whether self- compared to other-referential contexts (the use of "you" compared to "[another character]") increase attention for positive and negative trait adjectives across ERPs and memory in a child population.

Chapter 3: The Self-Referential and Positivity biases in Children.

3.1 Introduction

Converging evidence from behavioural and neuroimaging techniques suggests that self-referential processing is an important and unique aspect of social cognition in adults, as indicated by enhanced neural activation and improved incidental memory for self-relevant information (e.g., self-face recognition, Keenan et al., 2000; first person spatial navigation, Vogeley & Fink, 2003; self-descriptive word recognition, Hudson et al., 2020; Shestyuk & Deldin, 2010; Pereira et al., 2021). At times, an additional bias towards positive information is also found across behavioural and cortical responses in healthy adults, with recent studies suggesting that self-relevant information is encoded independently of affective information (Hudson et al., 2020; Pereira et al., 2021). However, to-date, the relation between these two dimensions has primarily been addressed in adults. Although it is well known that children develop a more realistic and adult-like self-concept around 10 years of age (Pfeifer et al., 2007), it is currently unclear whether the encoding of self-relevant information is integrated with valence information in childhood. The present study sought to address how children encode information that is related to the self compared to others, and how the valence of that information impacts behavioural and neural responses during encoding and subsequent memory performance.

The extent to which an individual prioritizes the encoding of self-referential information (i.e., self-referencing bias) is often assessed using the Self-Referential Encoding Task (SRET; Rogers et al, 1977). The SRET is a simple and child-friendly task in which participants are presented with a sequence of both positive and negative trait adjectives and are asked whether each adjective is true of themselves (in self-referential conditions) or of another person (e.g., Harry Potter, in other-referential conditions adapted from the original SRET). Following this endorsement phase, participants are presented with incidental memory tasks (free recall and/or recognition) to assess the depth of encoding of the information presented (see section 1.2). Typically developing children also display highly (often overly) positive self-perceptions, which become more realistic in early adolescence (Crone & Fuligni, 2020). This characteristically positive representation of oneself manifests as improved memory for positive relative to negative information in self-referential processing, which again is found in healthy adults (Auerbach et al., 2015; Auerbach, et al., 2016; Dainer-Best et al., 2017; Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010) and children (Troller-Renfree et al., 2017; Watson et al., 2007). This improved memory for positive information is thought to protect against internalizing disorders through ensuring positive (relative to negative) information is prioritized for storage in long term memory and integration into the self-concept (Derryberry & Reed, 1994; Frewen et al., 2008; Goldstein et al., 2015; Grafton et al., 2012).

Moreover, neuroimaging research provides insight into differences in brain activity while processing self-relevant and positive information during the SRET. Specifically, when Event Related Potentials (ERPs) are time locked to the presentation of the trait adjectives presented during the endorsement phase of the SRET, healthy adults exhibit enhanced amplitudes across the late positive potential (LPP) waveform in response to self- relative to other-referential information (between 400ms and 1000ms post stimulus onset; Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010; Section 1.1). These enhanced LPP waveforms are thought to reflect sustained processing of emotionally salient stimuli (between 400-600ms; the early LPP; Naumann et al., 1992) and affective encoding and memory storage (between 600-1200ms; the late LPP; Ruchkin et al., 1988). Moreover, healthy adults also display enhanced LPP amplitudes for positive relative to negative information in the SRET (Auerbach et al., 2015; Auerbach et al., 2016; Hertel & El-Messidi, 2006; Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010). However, as far as we know, the LPP in response to self- compared to other-referent cues has not been investigated in children, and the current literature examining ERP responses to emotional information in children is mixed. For example, the LPP in 5- to 8-year-old children is enhanced between 500-1000ms after viewing positive images, and between 500-1500ms after viewing negative images (Hajcak & Dennis, 2009). Others have found a general LPP enhancement in children aged 4-6 (Hua et al., 2014) and 5-8 years (Leventon et al., 2014; Solomon et al., 2012) in response to emotional (positive *and* negative) relative to neutral images. These mixed valence effects may suggest that children find positive and negative information equally salient and arousing during encoding. However, it remains unclear whether the LPP response during encoding of emotional information in children differs depending on the referent (self or other) of the information.

To better understand the roles of self-referential and positivity biases in children's emergent social cognition, it is critical to identify whether they act as two independent biases, or whether they interact to give rise to a *self-positivity* bias that uniquely favors children's processing of positive self-referential information. The bulk of past SRET studies (Auerbach et al., 2015; Auerbach et al., 2016; Dainer-Best et al., 2017; Hayden et al., 2014; Prieto et al., 1992; Quevedo et al., 2017; Ramel et al., 2007; for brief review, see Scher et al., 2005) exclusively examined valence processing across a single self-referential condition, leaving the possibility that any "self-positivity" effect was the positivity bias presented in one referent condition. Importantly, converging neuroimaging evidence does suggest that, in adults, differential neural areas are responsible for referent and valence information encoding. For instance, fMRI studies have shown that the prefrontal cortex (PFC; Crone & Fuligni, 2020; Johnson et al., 2002; Kelley et al., 2002; Mitchell et al., 2005; Northoff et al., 2006; Zysset et al., 2003; for review see Carrington & Bailey, 2009) and the anterior cingulate cortex (ACC; Modinos et al., 2009) are involved in self-referential thought and information processing. In contrast, affective information processing recruits the nucleus accumbens and the amygdala (Crone & Fuligni, 2020; Gee et al., 2013; Moran et al., 2006). Two recent studies have also concluded that referent and valence cues were not integrated in adults' ERPs during trait adjective encoding (Hudson et al., 2020; Pereira et al., 2021). These converging spatial and temporal neuroimaging results suggest that, in adults, referent and valence cues are encoded in parallel, existing as their own individual mechanisms across different brain areas.

The Current Study.

In sum, to my knowledge, there are no prior ERP studies with typically developing children explicitly examining the relation between referent and valence processing using the SRET. Therefore, in this study I examined the temporal unfolding of these biases using behavioural and ERP measures in a sample of 9- to 12-year-old children. This age group was of particular interest, as late childhood/early adolescence is a time in which children have a more realistic self-concept relative to younger groups (Crone & Fuligni, 2020; Pfeifer et al., 2007), but have yet to undergo prolonged social and emotional development over the course of adolescence (Eccles, 1999). These factors were important for the present study as the goal was to capture how referent and valence cues are processed in children, without the potential confounding effects of an underdeveloped self-concept or social and emotional pressures experienced through adolescence.

Consistent with recent adult findings (Hudson et al., 2020), I predicted that children would endorse more positive than negative trait adjectives and demonstrate enhanced ERP amplitudes (eLPP, lLPP) for positive trait adjectives, and trait adjectives encoded in a self-referential context. Given that referent and valence cues do not interact in adults' ERPs to trait adjectives (Hudson et al., 2020; Pereira et al., 2021), I predicted there would *not* be a significant interaction between referent and valence during trait adjective encoding on children's ERPs. Finally, I predicted that children would demonstrate improved incidental memory (recall, recognition, and memory sensitivity) for trait adjectives encoded in a self-referential context (regardless of valence) and for positive trait adjectives (regardless of referent). That is, I did not expect an interaction between referent and valence in memory.

3.2. Methods

3.2.1 Participants

Participants were recruited as part of a larger study of social cognition and socio-emotional functioning in middle childhood. The intention was to recruit 84 typically developing children to participate in this extended study, which anticipated gathering behavioural data from 42 dyadic partners (i.e., 84 individuals). However, recruitment was put on hold in March 2020 due to COVID-19 related local restrictions. At the onset of the pandemic, a total of 63 typically developing children between the ages of 9 and 12 (9.00-11.92 years; M = 10.16, SE = .098; 42 females; 78.8% white/Caucasian; mean household income of $75,000 to $99,999; summary of participant characteristics is presented in Appendix A, table A1) had participated. Participants were recruited through community events, social media (e.g., Facebook, Kijiji), and letters distributed to local schools. Exclusion criteria included a history of neurological or psychiatric disease, brain lesions, and a formal diagnosis of either autism spectrum disorder (ASD) or attention deficit hyperactivity disorder (ADHD). Participants were required to speak and read English as their first and primary language. Additionally, participants had to report knowing the character Gru from the Despicable Me franchise (n=58; Universal Studios, 2010) or, if unfamiliar with Gru, Harry Potter from the Harry Potter book/film series (n = 5; Warner Brothers, 2011) to be deemed sufficiently familiar with the character in the other condition of the SRET. Participants were excluded post-hoc if they asked the definition of more than 10% of the words in any condition (> 6 words; N = 1), resulting in a final sample of 62 children (M_{age} = 10.16 years, SD = .775; 42 female) with behavioural data. A power analysis was conducted using G-Power (version 3.1.9.4; Erdfelder et al., 1996), which deemed this sample of 62 participants sufficient to detect medium size interaction (η_p^2 of .06) across within-subjects 2 referent x 2 valence ANOVA with a power of .8 and η_p^2 of .06 (GPower 3.0 $n_{calculation}$ = 34). Since depression and anxiety are known to modulate SRET performance (i.e., Auerbach et al., 2016; Shestyuk & Deldin, 2010), this sample (N = 62) scored in the average normal t-score range on the self-reported Behaviour Assessment System for Children Third Edition (BASC-3; Reynolds & Kamphaus, 2015), anxiety[8] (M = 51.13; SD = 11.70; range 22-83) and depression (M = 52.71; SD = 9.26; Range 38-78) assessments.

[8] The Behaviour Assessment System for Children, Third Edition (BASC–3) is a comprehensive measure to evaluate the behaviour and self-perceptions of children and young adults. Questions are rated on a four-point scale ranging from Never (0) to Almost always (3). The BASC-3 contains 14 different subscales, with most alpha coefficients exceeding .85 for all ages.

3.2.2 Stimuli

The SRET was designed and administered using Experiment Builder (version 1.11.0.1316) with responses recorded using a game controller. To reduce head movements during the task, participants used a chinrest throughout the experiment, positioned 70cm in front of the screen. The same lists of trait adjectives from Chapter 2 were used (see Appendix B, Table B2 for lists of adjectives). Two lists were used in SRET experimental trials (referent conditions counterbalanced across participants; list order counterbalanced across participants), while the third list provided the distractors in the recognition task following the SRET.

The fictional character 'Gru' from Despicable Me was used as the primary subject of the other condition, as he is well-known to children in this cohort and possesses both positive and negative traits. This was important for the present study, as prior knowledge of the other character modulates behaviour responses across the SRET, with those considered closely related to the self (e.g., one's mother) receiving similar behavioural and memory responses to that of self-referential processing (Aron et al., 1991; see section 3.5 for more details on this effect). We validated the neutrality of Gru in a separate sample of children (N=23) who participated in a different, unrelated study. These children were asked, "*We're trying to figure out what characters from books or movies are really popular in kids your age. Today, I'm going to ask you about a few characters and you can tell me whether you know them or not. At the end, I'll ask you for two suggestions of characters that you think you know really well but I might not have asked about*". Within this sample, 100% of children were familiar with Gru while 87% of children were familiar with Harry Potter. In determining neutrality of characters, children reported Gru as having an average score of 2.83 (*SD*= .65) on a five-point Likert scale rating the goodness of the character (1= always bad, 2 = mostly bad, 3 = sometimes bad, sometimes good, 4 = mostly good, 5 = always good), representing a balanced representation of 'good versus bad'. This is in comparison to Harry Potter, where children rated the character more positively with an average score of 4.10 (*SD*= .78). In cases where participants were unfamiliar with Gru during the SRET experiment (5 of 63 participants), Harry Potter served as the subject of the other condition, having been used in past research involving the SRET (e.g., Henderson et al., 2009; Hudson et al., 2020; Knyazev, 2013)[9].

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[9] Analyses were conducted with and without the participants presented with Harry Potter to ensure the effects were not impacted by the change in character. All effects remained the same, so analyses were conducted on the entire sample to maintain power.

3.2.3 Procedure

The SRET consisted of three consecutive phases: endorsement, recall, and recognition (Figure 7). However, participants came to the lab under the pretense of completing the endorsement task and were unaware of the recall and recognition tasks. Before participants began the experimental phase of the task, they first underwent four minutes of baseline recording identical to that of Chapter 2. This ensured each participant had time to become comfortable and settled with the EEG and chin rest setup. The baseline EEG data and the self-report questionnaire data are not presented in this study. Self-report questionnaires were administered throughout the EEG set-up process.

Endorsement Task. Participants were seated in front of the testing computer and were read the task instructions by the experimenter. After a short series of practice trials, participants completed two blocks of experimental trials: one block corresponding to the self and one block to the other conditions (counterbalanced). At the beginning of each block, participants were informed who the referent of the trait adjectives would be (themselves or Gru).

Trials in the self and other conditions followed identical progressions (see Figure 7), with just the name of the referent presented at the end of the trial (you vs. Gru) being changed. Trials began with the presentation of a central fixation cross, appearing on screen jittered between 1500-1700ms. A trait adjective then appeared in the center of the screen for 200ms, presented in lowercase, size 50 Times New Roman font. A second fixation cross was presented for 1800ms. Following each adjective in the self condition, participants were prompted with the question “Does this word describe you?” and indicated ‘Yes’ and ‘No’ via button press on the game controller (‘left’ or ‘right’, mappings counterbalanced across participants). Prompts in the other condition read “Does this word describe Gru?”. Each condition presented all items from one of the two 64-word experimental lists, and word lists were counterbalanced across the conditions. Within each condition, words were pseudorandomized such that no more than two words of the same valence were presented in a row. EEG data were continuously recorded throughout the endorsement phase of the SRET (see Electrophysiology section below for details).

Recall Task. After completing the endorsement task, participants performed a distractor task (verbally counting backwards from 50), followed by a surprise recall task. Participants were handed a blank piece of paper and asked to write down all the adjectives they could recall from the endorsement task. After three minutes (or after indicating that they could not remember any additional items), participants’ response sheets were collected by the experimenter.

Recognition Task. Immediately following the recall task, participants were given a pencil-and-paper recognition task consisting of all 128 target trait adjectives from the endorsement task intermixed with an additional 64 distractor adjectives from the third list, for a total of 192 trait adjectives. All trait adjectives were presented in a randomized order, with no more than two words per word list or valence presented in a row. Participants were instructed to circle all words they recognized from the experiment.

After completing the SRET, participants were immediately debriefed on the deceptive nature of the task (i.e., not being told about the memory component beforehand). After re-consenting to the use of their data and indicating their willingness to continue with the study, participants went on to complete additional tasks as part of the broader study.

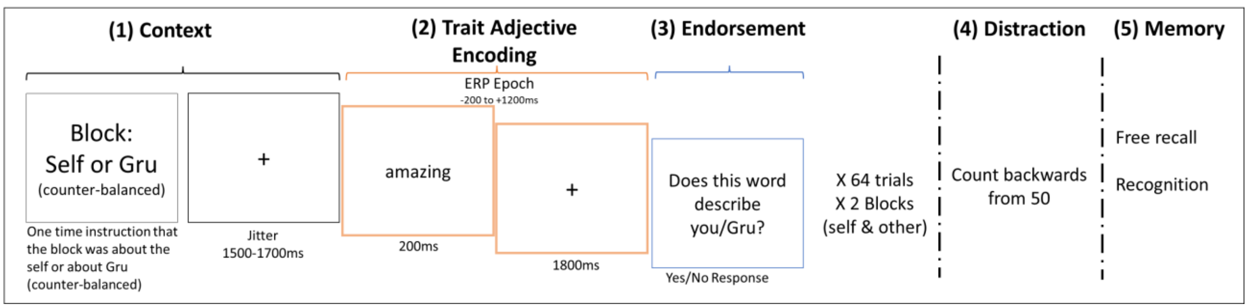

Figure 7. Study 2 trial progression.

Example trial from the SRET in the presenting self- and other relevant contexts (depending on the block; counterbalanced across participants). Participants were provided with (1) the context at the beginning of each block. ERPs were time locked to when participants (2) encoded positive and negative trait adjectives in the context of the referent. (3) The question prompt was then displayed for each positive and negative trait adjective, during which participants were instructed to respond 'Yes' or 'No' using the left or right buttons on the game controller. After both a self- and other-relevant block, participants completed (4) a distractor task before completing a (5) free recall and a recognition memory task.

3.2.4 Electrophysiological Recording

EEG was continuously recorded during the endorsement task at 500 Hz by an Acti64Champ (Brain Vision Solutions Inc.) with electrode impedances kept below 50 kOhms. Custom caps under the 10-20 system extended included 64 recording electrodes including PO9/PO10 and TP9/TP10 for additional coverage. Electrode sites F1, F2, AF3, and AF4 were excluded from the recording montage. Electrode Cz was used as the reference site during recording, with all data average-referenced offline.

3.3 Data Processing and Analyses

3.3.1 Behavioural data

To account for potential order effects (self, other vs. other, self), *order* was entered as a between-subjects factor in each behavioural analysis. Thus, a series of 2 (Referent: Self, Other) x 2 (Valence: Positive, Negative) x 2 (Order: First, Second) mixed model ANOVAs were conducted for each of the following indices.

Adjective endorsement. Endorsement scores were calculated for each of the four conditions (2 referent x 2 valence) as the number of adjectives attributed to the condition (i.e., the number of positive and negative adjectives to which the participant responded 'Yes' when asked "Does this word describe you (self) or Gru/Harry Potter (other)?".

Free recall. Recall scores were calculated as number of adjectives from each condition correctly recalled during the recall task. An adjective was considered correctly recalled if the root form of the word appearing in the endorsement task was produced (e.g., admirable would be accepted for admired).

Recognition. Recognition scores were calculated as the number of adjectives correctly identified ('hits') in the recognition task.

Memory sensitivity. Similar to Chapter 2, we accounted for cases in which participants incorrectly reported recognizing a distractor ('false alarms'). The calculation of *d'* requires hit and false alarm rates to fall between the values of 0 and 1, non-inclusive. As such, following recommendations by Macmillan and Creelman (2004), the formulas $\frac{0.5}{N}$ and $\frac{(N-0.5)}{N}$ were used to replace rates of 0 and 1, respectively, where N refers to the total number of targets/distractors in the condition (in each case, N = 32). Accordingly, across eight participants, 6 false alarm rates[10] and two hit rates[11] of 0 were replaced with adjusted values of .0156, while two hit rates[12] of 1 were replaced with adjusted values of .9844.

3.3.2 Event-Related Potential Data

EEG data were pre-processed offline using EEGlab version 13.6.5b (Delorme & Makeig, 2004) and ERPlab version 5.1.1.0 (http://erpinfo.org/erplab) under Matlab 2014b software (Mathworks, Inc.,

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[10] Two participants correctly rejected all Positive distractors, two correctly rejected all Negative distractors, and two correctly rejected all distractors (Positive and Negative).
[11] One participant incorrectly rejected all Self-Positive trait adjectives while another incorrectly rejected all Self-Negative adjectives.
[12] One participant correctly recalled all Self-Positive trait adjectives while another correctly recalled all Self-Negative adjectives.

2014). ERPs were time locked to the onset of the trait adjective presented. Raw data were first segmented into 1400ms long epochs including a 200ms baseline (-200ms, +1200ms) and were digitally band-pass filtered (0.01 – 30 Hz) using a two-way least-squares FIR filter. Trials with artifacts greater than ±70 μV were automatically rejected, with further trials manually rejected following visual inspection. After trial rejection, 9 participants had too few trials to remain in the analysis (i.e., less than 20 trials per condition). An additional 4 participants did not undergo EEG recording (refused: N = 1; incompatible hair style N = 3) leaving 49 participants for the ERP analyses (M_{age} = 10.18; SD = .750; 30 female). Participants had an average of 21.63 (SD = .321) trials per condition. Average waveforms were computed for each participant across each of the four conditions (self-positive, self-negative, other-positive, other-negative). The early LPP (hereafter eLPP; mean amplitude between 400-600 ms) and late LPP (hereafter lLPP; mean amplitude between 600-1200 ms) were averaged across the Frontal Central Midline (FCM) sites Fz, FCz, and Cz. However, previous research has identified the child LPP occurring across parietal sites rather than frontal sites as seen in adults (Hajcak & Dennis, 2009; Kujawa et al., 2012; Woody et al., 2019). Topographic maps of the present sample supported this parietal distribution (Figure 11; panel B), therefore statistics were run across both frontal (Fz, FCz, and Cz) and parietal (P1, P2, PO3, PO4, Pz, and POz) sets of electrodes. To further follow Hudson et al. (2020), the lLPP was divided into three time-windows (600-800 ms, 800-1000 ms, and 1000-1200 ms) to allow for a closer examination of the temporal dynamics of processing differences with a Bonferroni correction. Due to the relatively low number of trials per condition, we were unable to reliably use mass univariate statistics for this study.

Similar to the behavioural analyses, a separate analysis was conducted to ensure there were no order effects across any of the ERP components. As expected, no order effects emerged across any ERP analyses, thus this factor was dropped to maintain power.

The eLPP was subjected to a 2 (Referent: Self, Other) x 2 (Valence: Positive, Negative) repeated measures ANOVAs. The lLPP was first examined using a 2 Referent by 2 Valence by 3 Time (600-800ms; 800-1000ms; 1000-1200ms) ANOVA. To replicate Hudson et al. (2020), if Time-Window significantly interacted with Referent and/or Valence across the LPP, then each time-window was examined through an independent 2 X 2 ANOVA using a Bonferroni correction, with significance set to p = .016 (.05/3 Time-Windows).

3.4 Results

3.4.1 Behavioural Data.

Descriptive statistics for each behavioural measure by condition are presented in Table 2. Follow-ups of interaction effects that included order were assessed using independent samples t-tests across each condition (e.g., self-positive block 1 compared to self-positive block 2), with a Bonferroni corrected significant threshold of $p = .0125$ (.05/4 comparisons)

Endorsement. No effect of order or interactions between order and any other factor were found (all *p*'s > .278). The main effect of referent was not significant, $F(1,60) = .287$, MSE = 9.17, $p =.594$, $\eta_p^2 = .005$. There was a significant effect of valence, $F(1,60) = 142.37$, MSE = 41.45, $p < .001$, $\eta_p^2 = .704$, qualified by a referent by valence interaction, $F(1,60) = 126.05$, MSE = 49.90, $p < .001$, $\eta_p^2 = .678$. In the self-referential condition, participants endorsed significantly more positive than negative items, $t(61) = 26.62$, $p < .001$, while no difference between positive and negative items was found in the other-referential condition, $t(61) = -.178$, $p = .859$. Moreover, participants endorsed more self-positive than other-positive items, $t(1, 61) = 10.74$, $p < .001$, while endorsing more other-negative than self-negative items, $t(61) = -10.09$, $p < .001$ (Figure 8).

Free recall. The main effect of referent was not significant, $F(1,60) = .000$, MSE = 7.91, $p > .999$, η_p^2= .000. The main effect of valence was significant, $F(1,60) = 4.05$, MSE = 2.45, $p = .049$, $\eta_p^2 = .063$, with participants remembering more positive relative to negative items regardless of referent (Figure 8). The referent by valence interaction was not significant, $F(1, 60) =.093$, MSE = 2.95, $p = .761$, $\eta_p^2 = .002$, but the three-way interaction with order was significant, $F(1, 60) = 18.29$, MSE = 2.95, $p < .001$, $\eta_p^2 = .234$. Follow up analyses demonstrated that self-positive, $t(60) = .215$, $p = 830$, and other-negative, $t(55.45) = .730$, $p = .468$), recall rates were unaffected by order, but self-negative items were significantly better remembered when the self condition was presented second, reflecting a recency effect, $t(45.09) = -2.90$, $p = .006$. Additionally, memory for other-positive information was better remembered when the other condition was completed first, reflecting a primacy effect, $t(44.90) = -2.83$, $p = .007$ (Figure 9).

To account for errors in recall (incorrectly writing words which did not appear during the encoding phase), recall scores were converted to proportions of correctly and incorrectly recalled positive and negative words out of the total positive and negative words written (accurate and inaccurate). The main effect of valence disappeared, $t(61) = 1.50$, $p = .139$. Of the participants who recalled words which did not appear during the encoding phase (n = 32) these words were significantly more likely to be positive (M = 1.06; SD = 4.63) than negative (M = .52; SD = .844) in valence, $t(61) = 2.76$, $p = .008$.

Recognition. The main effect of referent was not significant, $F(1, 60) = .743$, MSE = 25.75, $p = .392$, η_p^2 = .012, nor was the main effect of valence, $F(1, 60) = .879$, MSE = 9.83, $p = .352$, $\eta_p^2 = .014$. The referent by valence interaction was not significant, $F(1, 60) =.400$, MSE = 9.64, $p = .530$, $\eta_p^2 = .007$, but there was a three-way interaction between referent, valence, and order, $F(1, 60) = 14.77$, $p < .001$, $\eta_p^2 = .198$. While no follow-up t-tests were significant across each condition, follow up 2 by 2 ANOVAs for each order revealed that this was driven by a referent by valence interaction when the other condition was presented in the first block, $F(1,31) = 14.29$, MSE = 6.98, $p < .001$, $\eta_p^2 = .315$, such that participants correctly recognized more other-positive than other-negative items, $t(31) = 3.97$, $p < .001$ (Figure 9).

In their recognition errors, participants were no more likely to incorrectly recognize positive or negative trait adjectives, $t(61) = -.810$, $p = .421$.

Memory sensitivity (*d'*). The main effect of referent was not significant, $F(1, 60) = .337$, MSE = .267, $p = .564$, $\eta_p^2 = .006$, and the main effect of valence was marginally significant, $F(1, 60) = 3.93$, MSE = .186, $p = .052$, $\eta_p^2 = .061$. The referent by valence interaction was not significant, $F(1, 60) = .657$, MSE = .093, $p = .421$, $\eta_p^2 = .011$, but the three-way interaction between referent, valence, and order was, $F(1, 60) = 17.75$, MSE = .093, $p < .001$, $\eta_p^2 = .228$. Follow up analyses showed that, similar to the effect on recall, participants were more accurate for other-positive items when other was presented first compared to second, $t(60) = 4.91$, $p < .001$, reflecting a primacy effect (Figure 9)[13].

Table 2. Means and standard deviations for the number of words endorsed, recalled, recognized, and for the memory sensitivity (d'), for the four conditions (blocked by referent; self-positive, self-negative, other-positive, other-negative). The maximum number of words per condition was 32.

		Self		Other	
Task		Mean	(SD)	Mean	(SD)
Endorsement	Positive	23.19	(4.21)	13.34	(6.10)
	Negative	3.34	(3.13)	13.61	(7.28)
Recall	Positive	2.71	(2.02)	2.81	(2.62)
	Negative	2.40	(2.28)	2.31	(1.69)
Recognition	Positive	19.26	(6.82)	19.02	(7.83)
	Negative	19.16	(7.05)	18.32	(7.43)
Memory sensitivity (*d'*)	Positive	1.33	(.69)	1.33	(.78)
	Negative	1.25	(.68)	1.18	(.67)

[13]Endorsement data for self-negative data, and recall for self-negative and other-positive, were all positively skewed (skewness statistic > 1.0). These variables were log-transformed, and analyses were re-run on this new data. Endorsement results demonstrated that the main effects of referent, $F(1,61) = 43.61$, MSE = .031, $p < .001$, $\eta_p^2 = .417$, became significant, and the main effect of Valence, and the Referent by Valence interaction remained significant. All main effects, interactions, and order effects remained unchanged within the recall data.

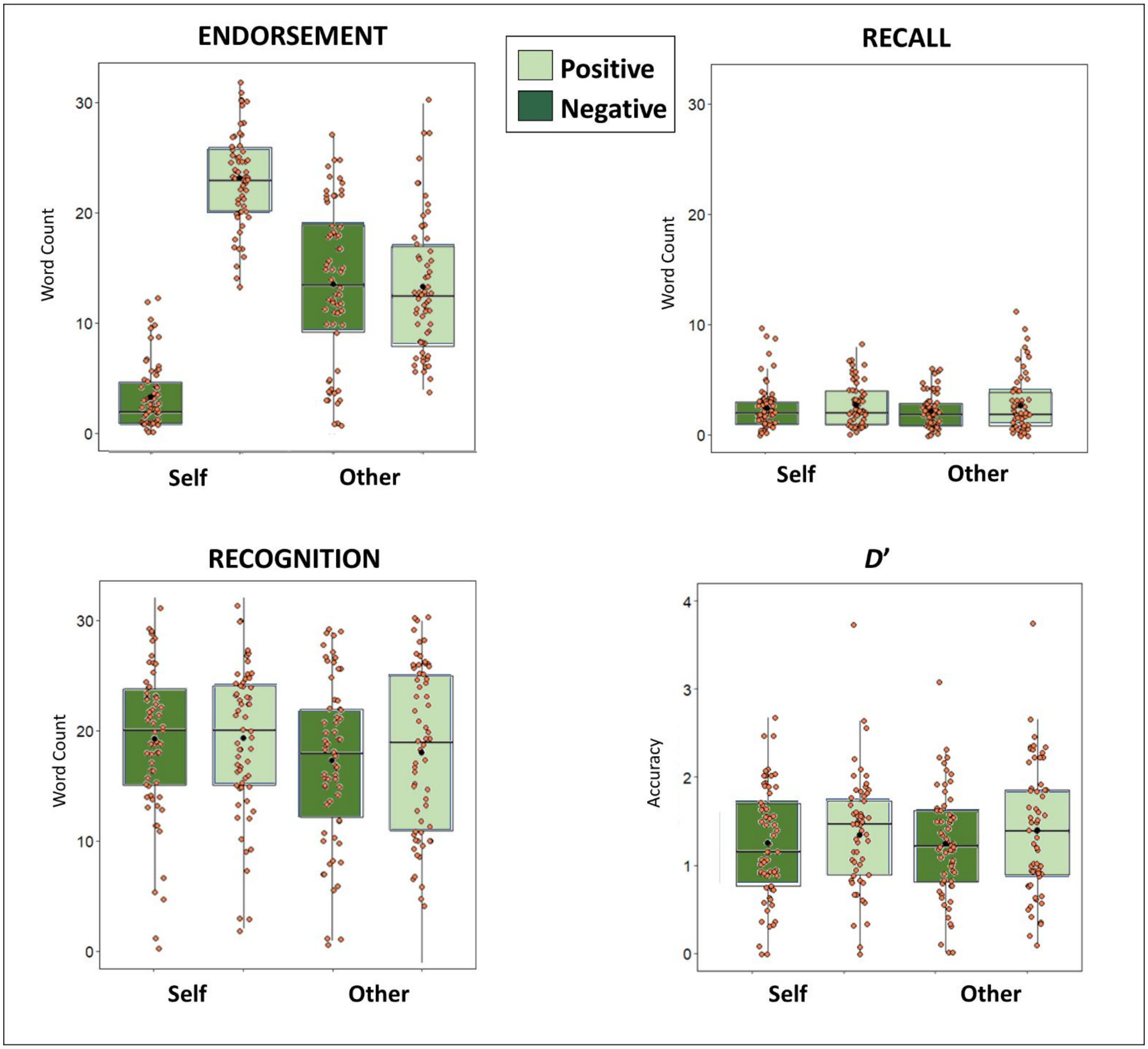


Figure 8. Study 2 behaviour effects.

Behavioural effects across the SRET with positive items presented in light green, and negative items presented in dark green within each box plot. The 25th(Q1) and 75th(Q3) percentile are represented by the upper and lower limits of each box plot, with the median indicated by a central horizontal line. A black dot marks each Mean within the boxplot. The upper and lower limits are reflected as the top and bottom of each whisker, respectively, calculated as Q1-1.5* Inter Quartile Range (IQR; minimum) and Q3 + 1.5*IQR (maximum), with outliers visible beyond these limits.

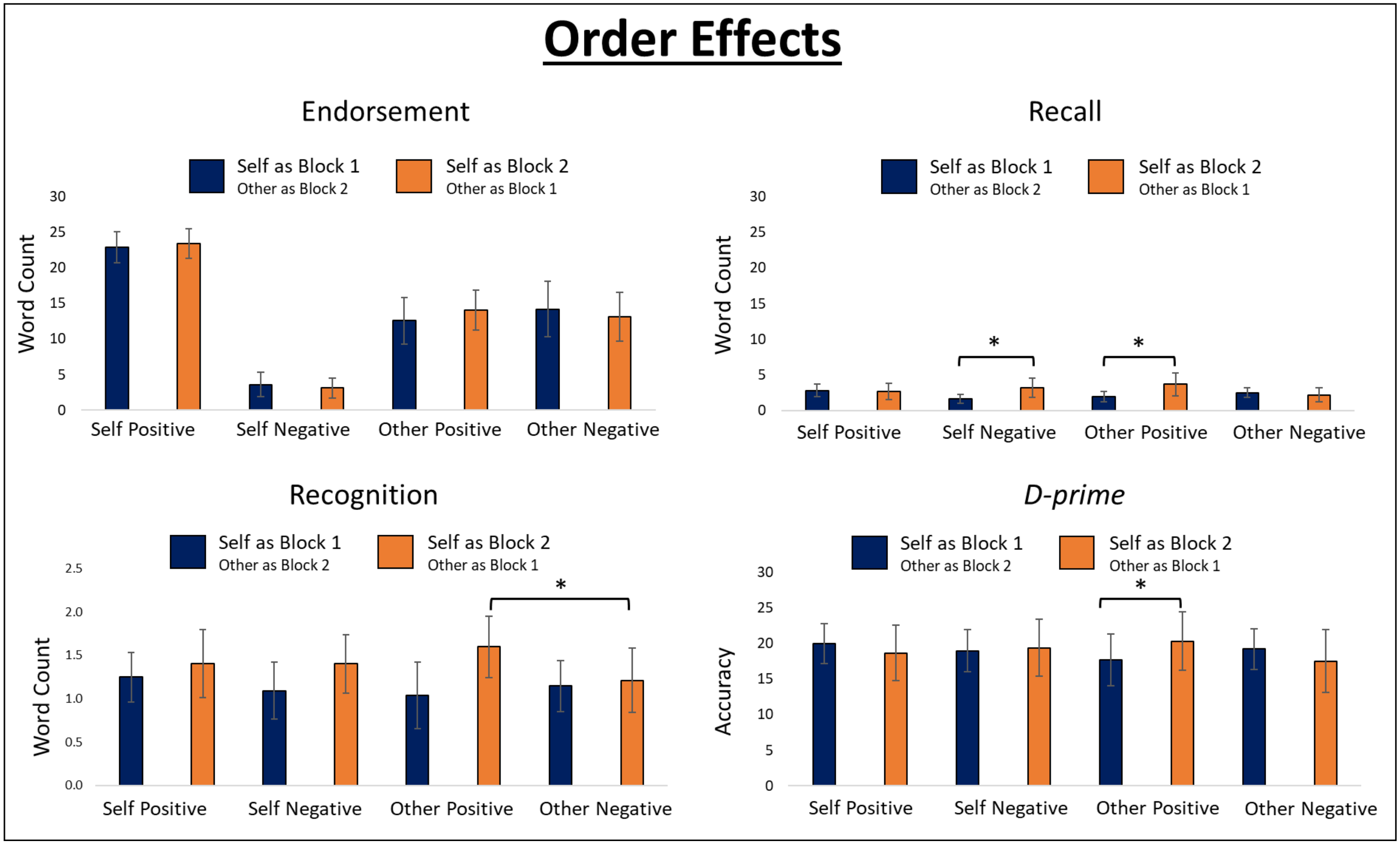


Figure 9. Study 2 order effects across memory.

Bar graphs representing order effects of each behavioural measure. Error bars represent standard deviation. The dark blue bars reflect performance when the self-referential condition was presented first, and the orange bars reflect performance when the self-referential condition was presented second. Significant differences are marked with an Asterix. The maximum number of words in each condition was 32.

3.4.2 ERP data.

Descriptive statistics for each ERP component by processing condition are reported in Table 3. As no effects were found on the frontocentral cluster for the LPP (all *p*'s> .159), results are reported for the parietal cluster only.

eLPP Parietal (400-600ms). There was a main effect of referent, with an increased amplitude for self-relevant compared to other-relevant items (Figure 10), $F(1, 48) = 9.86$, MSE = 6.80, $p = .003$, $\eta_p^2 = .170$. There was no effect of valence $F(1,48) = 2.82$, MSE = 6.10, $p = .099$, $\eta_p^2 = .056$, nor a referent-by-valence interaction $F(1,48) = 2.87$, MSE = 3.60, $p = .097$, $\eta_p^2 = .056$.

lLPP Parietal (600-800ms; 800-1000ms; 1000-1200ms). The main effect of time window was significant $F(1.46, 70.09) = 17.67$, MSE = 15.41, $p < .001$, $\eta_p^2 = .269$. There was no main effect of valence, $F(1, 48) = 1.03$, MSE = 19.09, $p = .750$, $\eta_p^2 = .002$, nor a valence by time-window interaction, $F(1.51, 72.45) = .693$, MSE = 2.60, $p = .465$, $\eta_p^2 = .014$. The main effect of referent was not significant, $F(1,48) = 1.05$, MSE = 20.40, $p = .311$, $\eta_p^2 = .021$, nor was the interaction between referent and valence, $F(1,44) = .013$, MSE = 12.04, $p = .908$, $\eta_p^2 < .001$, or the three-way interaction between referent, valence and time-window $F(1,48) = .002$, MSE = 13.72, $p = .961$, $\eta_p^2 < .001$. However, the referent by time-window interaction was significant, $F(1.61, 77.18) = 5.58$, MSE= 4.02, $p = .009$, $\eta_p^2 = .104$. To follow up on this two-way interaction, each time window (600-800ms; 800-1000ms; 1000-1200ms) was subjected to a 2 (referent) by 2 (valence) ANOVA, with a Bonferroni correction such that significance was set at $p = .016$, ignoring the effect of valence.

Analyses of the three windows of the lLPP demonstrated a main effect of referent between 600-800ms, $F(1, 48) = 7.63$, MSE = 7.41, $p = .008$, $\eta_p^2 = .137$, such that amplitudes for self-referential items were enhanced relative to other-relevant items (Figure 10). The effect of referent was no longer significant between 800-1200ms (800-1000ms: $F(1,48) = .015$, MSE = 9.81, $p = .903$; 1000-1200ms: $F(1,48) = 079$, MSE = 9.65, $p = .780$).

Table 3.Mean amplitudes (μV) and standard deviations averaged across parietal electrodes (Pz, P1, PO3, POz, P2, PO4) for the eLPP and lLPP, for each of the four conditions (self-positive, self-negative, other-positive, other-negative).

		Self-Positive		**Self-Negative**		**Other-Positive**		**Other-Negative**	
ERP		Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
eLPP	400-600ms	6.12	(3.84)	5.07	(4.31)	4.50	(3.25)	4.36	(3.54)
lLPP	600-800ms	6.25	(3.83)	6.22	(4.29)	5.08	(4.84)	5.25	(3.59)
	800-1000ms	5.28	(3.59)	5.83	(4.29)	5.59	(4.95)	5.64	(3.88)
	1000-1200ms	4.07	(3.87)	3.86	(4.24)	3.75	(4.10)	3.92	(3.20)

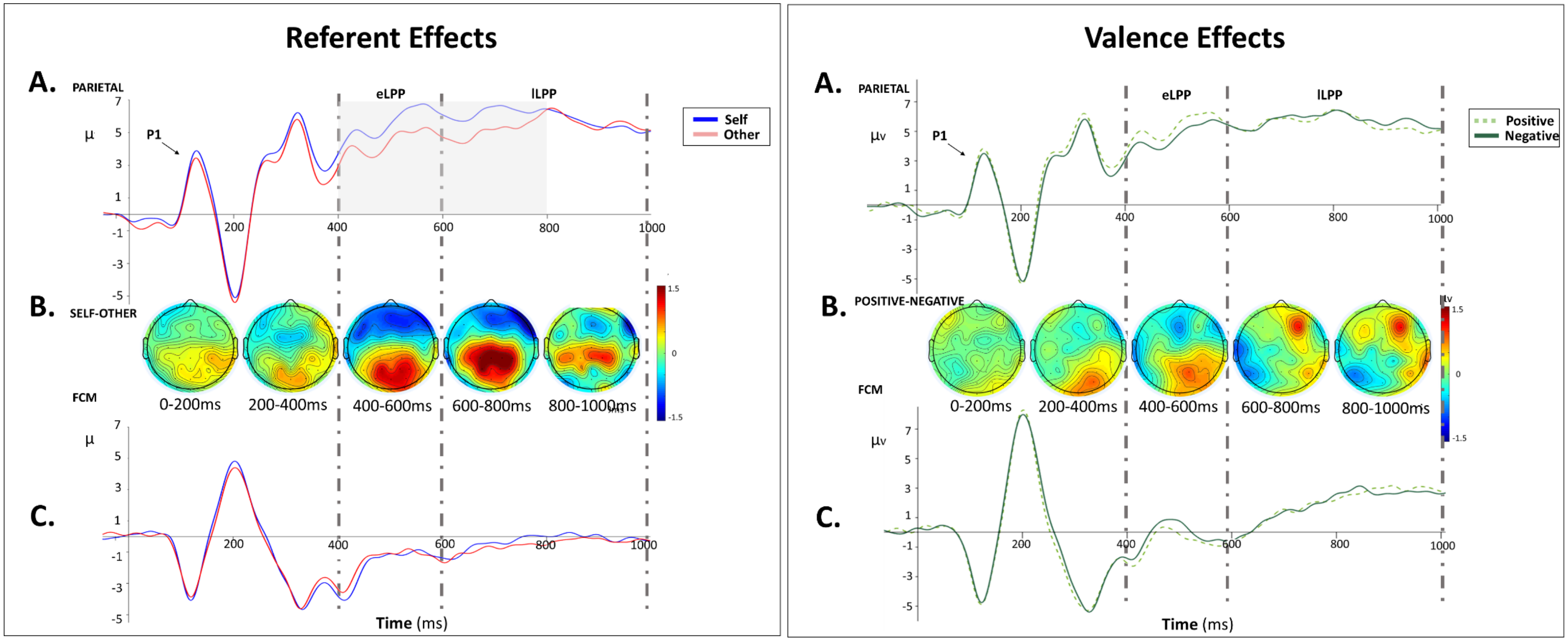


Figure 10. Study 2 ERP effects for the self-referential and positivity biases.

Mean group ERP responses to referent (left) and valence (right) cues, averaged across the parietal (panel A) and frontal-central-medial (FMC, panel C) clusters, with topographic maps (panel B) demonstrating the localization of the effects such that deeper red coloring reflects a larger Self-Other (left) or Positive-Negative (right) amplitude difference. These topographic maps support the reference effects across parietal electrodes (panel B; left), where amplitudes for self-referential items were enhanced between 400-800ms relative to other-relevant items (encompassing the eLPP and the beginning of the lLPP). Alternatively, valence effects were not statistically significant in any time window, as reflected by noisier maps (panel B; right).

3.4.3 Results Summary

Participants endorsed (responded 'Yes') significantly more positive and fewer negative trait adjectives in the self-referential condition, a difference not seen in the other-referential context. Participants displayed a more positive parietal LPP for self- compared to other-referential trait adjectives. There was no effect of valence, or a referent by valence interaction across ERPs.

Participants recalled more positive relative to negative trait adjectives, regardless of referent; however, this effect disappeared when errors in recall were taken into account. While there was no main effect of referent, there were interesting order effects on memory. Participants recalled significantly more self-negative trait adjectives when the self-referential condition was presented second, whereas block order was unrelated to recall for self-positive trait adjectives. In contrast, other-positive trait adjectives were better recalled and more accurately recognized (*d'*) when the other-referent condition was presented first.

3.5 Discussion

The goal of the present study was to examine children's encoding and memory for positive and negative trait adjectives referring to themselves or a familiar but fictional character. As predicted, participants endorsed more positive than negative trait adjectives (i.e., a positivity bias) when asked to reflect on themselves. Despite this clear endorsement bias for positive self-referential trait adjectives there was no evidence of preferential processing of positive information across ERPs. Instead, participants displayed enhanced parietal LPP amplitudes when encoding trait adjectives in the self- compared to other-referential contexts between 400-800ms, regardless of the valence of the information. In contrast to previous work, participants did not display improved memory for trait adjectives encoded in the self-referential context. Instead, participants demonstrated improved recall for positive relative to negative trait adjectives, regardless of whether they were encoded in the context of themselves or a fictional character. Further, free recall and memory sensitivity were affected by the order of blocked referent conditions but not in a systematic way.

During the endorsement phase of the task, a strong effect of referent was present across behaviour and ERPs, such that participants displayed a particular propensity to endorse more positive than negative traits about themselves but displayed no difference in endorsement of positive and negative information about a previously validated neutral other. Across ERPs, more positive LPP amplitudes were apparent for trait adjectives encoded in a self- compared to other-referential context, regardless of valence. As far as I know, this is the first study to replicate the effects of referent on LPP responses in a large sample of children, an effect previously reported in adults (i.e., Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010). Temporally, the LPP effect was consistent with those previously reported in adults, although the effect was localized to parietal sites rather than frontal sites as reported in adults. This parietal LPP response has also been observed in children's responses to emotionally salient relative to neutral images (Hajcak & Dennis, 2009; Hua et al., 2014; Leventon et al., 2014; Solomon et al., 2012), suggesting that in general, adults and children process motivationally relevant cues along a similar time course but that these responses differ in their localization. While the present study cannot speak to the specific neural generators involved, the results do suggest that self-referential information engages sustained attention to a greater degree relative to other-referential information during middle childhood.

Contrary to my hypotheses, the enhanced neural encoding for trait adjectives presented in a self- compared to other-referential context did not translate into improved memory performance for these stimuli. This was unexpected given the robust memory effects for self-referential information in past studies and across various types of stimuli and study designs (e.g., trait adjectives: Chapter 2; Burrows et al., 2016; Henderson et al., 2009; Hudson et al., 2020; Pereira et al., 2021; Turk et al., 2008; faces: McCrackin et al., 2021). The lack of memory effects in the present study may have been a result of the length of the word lists (64 relative to 42 in other child SRET paradigms, i.e., Burrows et al., 2017; Henderson et al., 2009). Indeed, even in adult samples, 64 words resulted in relatively low free recall rates (see Hudson et al., 2020; Chapter 2). Importantly, this design decision was driven by a need to collect sufficient trials to allow for reliable ERP analyses using the traditional analysis approach, thus future studies should consider the likely cost to memory incurred by the trial count. Using the same trial count, Hudson et al. (2020) found that adults recalled on average 3.07 words per condition, while children in the present sample recalled 2.55 words per condition. Based on this similar memory performance and LPP responses to self- compared to other-relevant information between this study here and in adults, it appears that 9- to 12-year-old children have established fairly adult-like affective self-referential processing abilities. One way to fully eliminate fatigue as a confounding factor in the assessment of self-referential memory in adults and children would be to administer the memory tests after a smaller subset of words.

Consistent with my predictions, recall memory (but not neural activity at encoding) was enhanced for positive relative to negative trait adjectives (regardless of referent), although this effect was not significant when errors were taken into account. This propensity to remember positive relative to negative items was also reflected in participants' recall false alarm rates (i.e., saying they previously saw a word they had not) as they were more likely to write down positive relative to negative trait adjectives. This finding is also consistent with the well-documented positivity bias commonly reported (although findings are mixed) in both child (Burrows et al., 2016; Henderson et al., 2009) and adult samples (Auerbach et al., 2015; Auerbach et al., 2016; Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010; Symons & Johnson, 1997), reflecting a general propensity to perceive oneself (and the world) in a positive light (Watson et al., 2007). Interestingly, while memory for self-positive information was not impacted by block order, recall for self-negative words was enhanced when adjectives were processed in relation to the self in the second block, which occurred immediately before the memory tasks. Moreover, while memory for other-negative information was not impacted by referent order, participants recalled more other-positive words when this information was presented in the first block, which occurred well before the memory tasks. These results may reflect a difference in consolidating positive information depending on the relevance of the information to the self. That is, self-positive information is quickly and effectively stored into long-term memory during encoding, resulting in no difference in positive self-referential memory across block order. In contrast, storage of negative self-relevant information remains in short term memory but is effectively prevented from becoming stored into long-term memory (a topic returned to in Chapter 5), resulting in a recency effect. This may reflect the proposed protective function of the self-positivity bias, such that self-positive information (supporting a positive self-concept) is prioritized for storage into long-term memory, whereas self-negative information may not be similarly prioritized. Further, the improved recall and recognition memory and accuracy for positive information about another person may take longer to store relative to self-referential information, yet still undergoes deeper processing and storage into long-term memory relative to negative information.

It is important to note that the choice of ‘other’ in these paradigms may be influential in both the behavioural and cortical responses between self- and other-referential processing. While the “Gru” character was validated in a separate sample of children (and rated as neutral in our sample here) to ensure this protagonist was viewed as neutral, other versions of the SRET have included characters which participants had previous positive bias for, as evident by the endorsement (‘yes’ response) to more positive than negative words (i.e., Harry Potter: Hudson et al., 2020; Lombardo et al., 2007; Bill Clinton: Shestyuk & Deldin, 2010). These pre-existing biases would certainly skew the endorsement data of the other character but have unknown effects on the cortical encoding of affective trait adjectives. Future work should compare ERP responses during the SRET to characters varying in their positive or negative attributes to determine how these biases may skew the ERP data. Moreover, the proximity of closeness to an individual (i.e., ones’ own mother compared to an unknown other) also impacts the memory of self-compared to other referential information (Aron et al., 1991), such that the improved memory effect for the Self is minimized or even eliminated as closeness increases (for review see Symons & Johnson., 1997). This is interpreted to reflect that close partners are considered part of the self-concept and may even share similar characteristics and traits (Aron et al., 1991). However, it remains unknown whether children are similarly influenced by the closeness of the other protagonist, and whether this impacts ERPs and memory in a graded manner dependent on the proximity of closeness to the other protagonist (see Section 5.3 for further discussion).

The present study demonstrates that children display unique biases in processing the referent and valence of social information. Similar to adults, children's attention is enhanced following a self- compared to other-referential cue, as indexed by more positive LPP amplitudes. I found no support of a positivity bias in children's neural encoding. Memory performance in this cohort remains unclear, likely a limitation of the study design. Interestingly, memory was impacted by the order of the referent cue (given the blocked design), such that positive and negative information is differentially consolidated depending on the relevance of that information to the self. This pattern of memory may suggest that referent cues modulate the emotional reappraisal mechanisms in consolidating and storing affective information. Future work should extend the SRET by including an ERP measure of *memory retrieval* across development by time-locking ERPs to the presentation of each trait adjective during the recognition task (see Section 5.2 for further discussion). Moreover, given that the present study found no encoding differences between positive and negative trait adjectives, future work should include a set of neutral words to determine how positive and negative information is encoded relative to neutral items across ERPs. It may also be beneficial to explore the encoding of referent and valence cues across different age groups to determine if and when positive and negative information become more specialized during encoding (i.e., is there an age where differences in encoding positive and negative stimuli can be captured across ERPs?), and what effect this may have on information consolidation and memory retrieval.

Having shed light on how children attend to and encode trait adjective information about themselves and others, the final goal of my dissertation was to assess how individual differences in the extent of these attention biases captured in the lab might contribute to children's real-world social behaviours. While it is theorized that the attentional biases captured across the SRET are associated with temperament and adaptive social development (see section 1.3), as far as I know, no study has explicitly examined these associations. Thus, Chapter 4 sought to map the self-referential and positivity biases captured across ERPs and memory indices onto temperament, and to explore how temperament and attentional biases influence children's behaviours during a live interaction with an unfamiliar peer.

Chapter 4: Temperament, the Self-Referential and Positivity biases, and Children's Conversational Style during a Live Interaction.

4.1 Introduction

Human beings engage in complex social behaviours including cooperation, sharing, and conversational turn-taking, which are all considered critical for adaptive development (for review, see Sanson, et al., 2004). Of particular interest for the present study is the ability to engage in effective conversational exchanges with novel peers, which sets the stage for the development of closer relationships. It has been proposed that the way in which children approach novel social interactions is influenced in part by one's inborn, biologically-based temperament (see section 1.3), and in turn one's style of attending to and processing social information (Jensen-Campbell et al., 2002; Rubin et al., 2011). In separate lines of research, the self-referential and positivity biases are also considered crucial for adaptive social development (see section 1.1 and 1.2) insofar as they guide the interpretation and memory storage of social information in the moment (Chapters 2 and 3) and over the course of the lifespan. It is therefore possible that one's temperament and these information processing biases are related, and both may contribute to individual differences in children's observable social behaviours. Therefore, in this final chapter, I sought to explore whether individual differences in temperament and the self-referential and positivity biases are (1) related to each other; (2) associated with children's conversational styles during a live interaction with an unfamiliar peer; and (3) whether the association between temperament and behaviour is mediated by the self-referential and cognitive biases.

Previous work demonstrates temperament is associated with social behaviours during infancy (Carey, 1974; Komsi et al., 2006; Putnam et al., 2001), early childhood (i.e., Dollar & Stifter, 2012; Gülay, 2012; Mathieson & Banerjee, 2010), adolescence (Putnam et al., 2001) and adulthood (Martowski, 2014). Of relevance to the present study are the temperamental factors of surgency and effortful control (EC), which are central components of Mary Rothbart's temperament model (1981). Rothbart posits that optimal developmental outcomes arise from the combined influence of a child's level of reactivity (i.e., surgency) and their self-regulatory capacities (i.e., EC). Temperamental Surgency describes one's tendency to approach (high surgency) or withdraw (low surgency) in novel or challenging situations (Rothbart et al., 2006), and is indexed by three subdimensions: high intensity pleasure (pleasure derived from participating in arousing or novel activities), fear (negative affect in response to the anticipation of novelty; reverse scored); and shyness (behavioural withdrawal from social novelty; reverse scored). High levels of surgency are expressed as quick and eager approach to novel people, places, and objects and is generally associated with adaptive social functioning including the formation of high-quality friendships (Rothbart, 2007; Rothbart & Rueda, 2005; Sanson et al., 2004). In contrast, low levels of surgency are expressed as avoidance or withdrawal from novelty, and are associated with anxiety, fear, and wariness in response to novel people, places, and things (Hipson & Séguin, 2016). The complementary factor of EC describes one's ability to regulate these initial reactions in a way that supports goal directed behaviour (Rothbart & Rueda 2005; for review, see Sanson et al., 2004). EC is also indexed by three subdimensions: inhibitory control (the capacity to plan and inhibit inappropriate responses); attentional focus (the capacity to focus or shift attention when desired); and activation control (the capacity to complete a task when there is a tendency to avoid it; Rothbart, Ellis, & Posner 2011). High EC is generally associated with positive developmental outcomes including academic achievement and social and emotional adaptation across the lifespan (Eisenberg et al., 2006; Pike & Atzaba-Poria, 2003; Rothbart, 2007; for review, see Putnam & Stifter, 2008). In contrast, low EC generally increases risk for both internalizing and externalizing behaviour problems (Gross, 2011). I would therefore expect that individuals who are high in temperamental surgency and EC will be more engaged in their conversations, reflected in open conversational styles (i.e., initiating and maintaining conversations) and being willing to share personal information to develop a meaningful connection.

More recent studies of temperament have moved beyond examining the main effects of temperament on social behaviour to consider exactly *how* and *why* temperament impacts behaviour over time (for review, see Sanson et al., 2004). I am specifically interested in understanding whether individual differences in children's self-referential and positivity biases (Chapter 3) mediate the relations between temperament and social functioning. The self-referential bias is fundamental for social development across the lifespan (see section 1.3), being thought to scaffold children's understanding of the thoughts and feelings of others (Eisenberg et al., 2015). The positivity bias is also critical for normative development by shifting attention away from negative social cues and toward positive cues, providing an adaptive bias for constructing a self-concept (section 1.3; Alfano et al., 1994; Andrews et al., 2020; Crozier, 1995; Eccles, 1999; Hallion & Ruscio, 2011). Further support for the involvement of these biases in effective social behaviour stems from populations with impairments in both these cognitive biases and social outcomes. For example, individuals with depression fail to demonstrate the typical positivity bias and instead show enhanced memory for negative (as opposed to positive) self-elaborations (i.e., "I must have given the wrong answer; I am not capable of succeeding this course", Everaert et al., 2012), negative self-relevant information (Auerbach et al., 2015; Bone et al., 2021; Dainer-Best et al., 2017; Shestyuk & Deldin, 2010), and negative interpretation biases in which neutral stimuli are interpreted as negative (Beesdo et al., 2007; Everaert et al., 2012). Prominent theories of depression argue that these biases result from maladaptive core beliefs about the self and an inability to disengage from negative social and self-referential information which result in the misinterpretation of social cues (Dozois & Frewen, 2006; for reviews, see Everaert et al., 2012; Spurr & Stopa, 2002). Based on these literatures, it is possible that the self-referential and positivity biases support one's style of attending to and engaging with social information, which modulates social behaviours both in the moment (i.e., an open and positive conversational style), and across the lifespan.

Bringing the literature on temperament and information processing biases together, I propose that the approach motivation described by temperamental surgency (Rothbart & Bates, 2006) may be positively associated with the extent of initial attention capture during the encoding of self- (vs. other) referential information (Chapter 3). In contrast, the regulatory control associated with EC (Rothbart & Bates, 2006) may be positively associated with the extent to which individuals elaborate on and ultimately store positive (vs. negative) information in memory. In support of these hypotheses, my prior studies demonstrated heightened attention capture for self- compared to other-referential cues, reflected in amplified ratings of subjective feelings and arousal (Chapter 2), and increased amplitudes across the late positive potential (LPP) ERP waveform (Chapters 2 and 3). In turn, stimuli encoded in a self- compared to other-referential context are better remembered in adults (Chapter 2). In children, memory for positive relative to negative information was modulated by the order in which self- and other-referential cues were presented, ultimately revealing a primacy effect for storing positive relative to negative self-relevant information (Chapter 3). As discussed in Chapter 3, the differences in memory performance for positive and negative information depending on the order of the referent cue may reflect the protective nature of the positivity-bias, which works to effectively down-regulate consolidation of negative information in normative populations.

The Current Study.

In sum, the present study sought (1) to determine whether surgency and EC are associated with social cognitive biases captured within the lab (Chapter 3); (2) to operationalize the self-referential and positivity biases from children's naturally occurring conversational utterances as they get to know a previously unfamiliar peer; and (3) determine if individual differences in temperament and cognitive biases are related to children's conversation styles. The current study methodologically extends past work by observing children during a *Get to Know You* task which assesses children's spontaneous unstructured live conversation with an unfamiliar peer (Degnan et al., 2014; Penela et al., 2015; Walker et al., 2014), rather than relying on parent reports of their child's typical behaviours. I designed a novel coding scheme to quantify engagement (i.e., open versus closed conversational style) and the self-referential (i.e., talking about specific traits about themselves) and positivity biases (i.e., talking about positive information) from children's conversational styles during their dyadic exchanges. These coded behaviours were then examined in relation to individual differences in cognitive biases as assessed behaviourally and physiologically during the Self-Referential Encoding Task (SRET; Rogers, Kuiper, & Kirker 1977; see Chapter 3), and to self-reports of temperamental surgency and EC.

It was hypothesized that temperamental (a) surgency and (b) EC would be positively associated with children's adaptive conversational style with an unfamiliar peer (e.g., the tendency to share trait and fact information about the self; sharing more positive than negative information; maintaining an open relative to closed conversational exchange; Hypotheses 1a and 1b). It was further hypothesized that (a) surgency would be associated with enhanced ERP amplitudes for self- compared to other-relevant information during information encoding (Hypothesis 2a), and (b) EC would be associated with increased memory performance for positive relative to negative trait adjectives in the SRET (Hypothesis 2b). These physiological and behavioural indices of the self-referential and positivity biases were also hypothesized to be positively associated with adaptive conversational style (Hypothesis 3a and 3b). Finally, it was hypothesized that self-referential and positivity biases would at least partially mediate the association between temperament and conversational style (Hypothesis 4).

4.2 Method

4.2.1 Participants.

The participants in the present study were the same sample reported on in Chapter 3. In one visit (visit order counterbalanced across participants), children participated in an EEG study (see Chapter 3) in which ERP and behavioural indices of social information processing biases were assessed using the SRET. After data cleaning, 62 participants had usable behavioural data and 49 participants had usable ERP data (summary of participant characteristics is presented in Appendix A, table A1). In a separate visit (roughly 1 week later), participants were matched with a same-age, same-gender, but unfamiliar peer, and together they participated in a series of dyadic activities, including an unstructured *Get to Know You* activity. Prior to participating in each visit, parents provided informed consent and children provided informed assent.

4.2.2 Self-report Measures.

The Early Adolescent Temperament Questionnaire - revised (EATQ-r; Ellis & Rothbart, 2002)**.** The EATQ-r is a self-report assessment of temperament for 9- to 15-year-olds. Items describe reactions to common daily situations and participants rate how true each statement is of him/herself on a scale of 1 (almost always untrue) to 5 (almost always true). The EATQ assesses three broad temperament factors: effortful control, negative emotionality, and surgency through the assessment of 16 subdimensions.

Surgency and effortful control were of particular interest in the current study. Surgency (α = .78; 16 items) is indexed by the average of three subdimensions: high intensity pleasure/surgency (6 Items; α = .71), fear (reverse scored; 6 items; α = .65) and shyness (reverse scored; 4 items; α = .82). Sample items include "*I think it would be exciting to move to a new city*"; "*I would not be afraid to try a risky sport, like deep-sea diving"*. Effortful control (α = .75; 16 items) is indexed by the average of three subdimensions: inhibitory control (5 items; α = .69), attention (6 items; α = .67), and Activation control (5 items; α = .76). Sample items include "*I Finish my homework before the due date"; "I can stick with my plans and goals"*.

4.2.3 Procedure.

The Self-Referential Encoding task (SRET; for full details see Chapter 3).

There were three consecutive phases of the SRET: (1) endorsement, (2) recall, and (3) recognition (see Figure 7 in Chapter 3 for SRET progression). To index the magnitude of the Self-Referential (Self-Other) and Positivity (Positive-Negative) biases, a series of behavioural DVs were computed using difference scores (see Table 4 for a summary of DVs; see Table 5 for descriptive statistics and summary of effects from Chapter 3).

Table 4. Summary and descriptions of SRET dependent variables.

DV	Operational Definition	Self-referential Bias calculation Self - Other	Positivity Bias calculation Positive - Negative
Recall	Number of adjectives correctly produced.	Number of adjectives correctly recalled in the Self condition minus the number of words correctly recalled in the Other condition, regardless of valence.	Number of Positive adjectives correctly recalled minus the number of Negative words correctly recalled, regardless of referent condition.
Memory sensitivity (*d'*)	The standardized probability of correctly recognizing a target adjective subtracted from the standardized probability of incorrectly recognizing a distractor.	Sensitivity scores from the Self condition minus the sensitivity scores in the Other condition, regardless of valence.	Sensitivity towards Positive trait adjectives minus sensitivity scores towards Negative trait adjectives regardless of referent condition.
(early and late) Late Positive Potential; ERP waveform between 400-800ms	ERP amplitudes recorded in response to the trait adjective presented during the endorsement phase of the SRET.	ERP amplitudes in response to trait adjectives presented in the Self condition subtracting the ERP amplitudes in response to trait adjectives in the Other condition, regardless of valence.	ERP amplitudes in response to Positive trait adjectives subtracting the ERP amplitudes in response to Negative trait adjectives, regardless of referent condition.

Table 5. Summary of SRET results from Chapter 3.

Task			Self Mean	Self SD	Other Mean	Other SD	Results Summary
Recall							
		Positive	2.71	(2.02)	2.81	(2.62)	Positive > Negative
		Negative	2.40	(2.28)	2.31	(1.69)	
Recognition							
		Positive	19.26	(6.82)	19.02	(7.83)	ns
		Negative	19.16	(7.05)	18.32	(7.43)	
Memory sensitivity (*d'*)							
		Positive	1.33	(.69)	1.33	(.78)	Positive > Negative
		Negative	1.25	(.68)	1.18	(.67)	(marginal)
eLPP component							
	400-600ms	Positive	6.12	(3.84)	4.50	(3.25)	
		Negative	5.07	(4.31)	4.38	(3.54)	Self > Other
lLPP component							
	600-800ms	Positive	6.25	(3.83)	5.08	(4.84)	
		Negative	6.22	(4.29)	5.25	(3.59)	Self > Other
	800-1000ms	Positive	5.28	(3.59)	5.59	(4.95)	ns
		Negative	5.83	(4.29)	5.64	(3.88)	
	1000-1200ms	Positive	4.07	(3.87)	3.75	(4.10)	ns
		Negative	3.86	(4.24)	3.92	(3.20)	

Data Reduction: SRET variables.

The results from Chapter 3 (see Table 5), demonstrated that the effect of referent was evident in the ERP indices at encoding and the effect of valence was evident on the behavioural indices of memory performance. To reduce the number of variables included in the current analysis, inter-relations among (a) self-other difference scores on the LPP at 400-600 and 600-800ms time windows, and (b) the positive-negative difference scores for recall and memory sensitivity, were examined.

Zero-order correlations revealed that the self-other ERP amplitude difference scores in the 400-600ms and 600-800ms time windows were significantly and positively correlated, $r(47) = .70$, $p < .001$. Cronbach's alpha was calculated using SPSS Statistics 22 of the ERP difference scores was deemed good with an $\alpha = .82$, thus the self-other ERP amplitude difference scores were averaged together to create a single index of self-referential bias (see Table 6 for descriptive information).

To examine the relations between positive-negative difference scores on recall and memory sensitivity, difference scores were first z-transformed to account for the different units and scales of measurement. While these facets of memory are typically considered to be separate constructs in the extant literature, based on the novelty of this study we wanted to ensure statistically that these aspects of memory were indeed separate. The difference scores between positive and negative recall and memory sensitivity were positively correlated, $r(60) = .302$, $p = .017$. However, Cronbach's alpha was deemed unacceptable with an $\alpha = .46$. Thus, while correlated, there was not sufficient evidence to suggest these indices captured the same construct. Therefore, each non-transformed memory score was used to test the study hypotheses (see Table 6 for descriptive information).

Table 6. Composite SRET descriptive information, with means and standard deviations presented in parentheses. Higher (more positive) scores indicate an increased ERP bias towards self- compared to other-referential trait adjectives (measured in microvolts) and memory for positive relative to negative information.

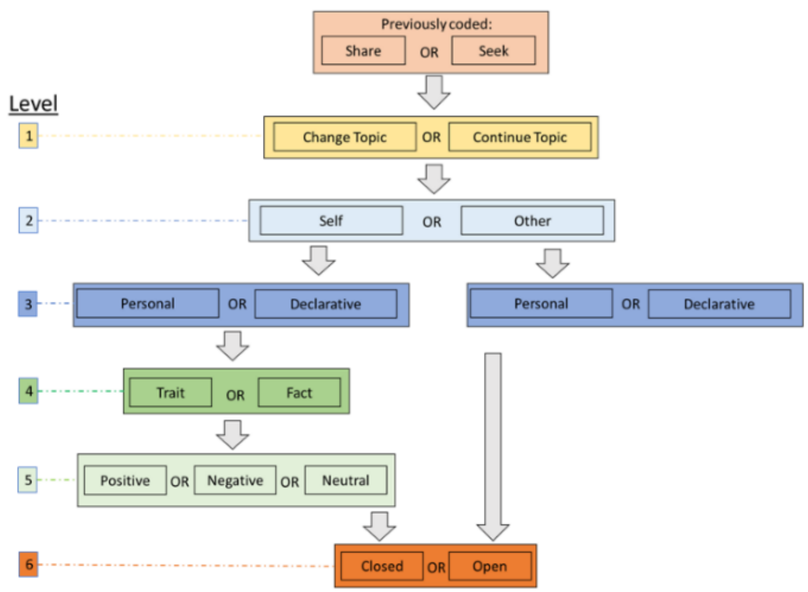
Composite Score	**Mean (SD)**
Self-Other (SO) ERP score	1.12 μV (1.45 μV)
Positive-Negative (PN) Recall score	.81 (3.1)
Positive-Negative (PN) Memory Sensitivity score	.11 (.44)

The Get to Know You (GTKY) Task.

Children visited the lab at the same time as a same-age, same-gender, but unfamiliar peer, to complete a series of dyadic interaction tasks. Each child was consented in a separate room before being led one at a time into the testing room by the experimenter. The children were seated across from one another at a table situated in front of a one-way mirror, which allowed researchers to monitor the session. Unknown to the children, two video cameras were set up in opposite corners of the testing room to record the children's behaviour throughout the task. A ceiling-mounted microphone in the middle of the room was used to record all vocalizations. Once comfortably situated in the room, the experimenter said, "*I have forgotten something. Why don't you get to know each other while I finish setting up?"* The experimenter provided no further instructions and left the children alone for 5 minutes.

Behavioural Coding.

The 5-minute unstructured interactions were reviewed and coded off-line from video using the Mangold Interact Software (Mangold, 2020). Coders were able to watch the 5-minute segment as many times as needed to make the necessary coding decisions. The start of the coding epoch was defined as the point at which the experimenter closed the testing room door or when either child first vocalized to the other child after the researcher stopped speaking, whichever occurred first. The end of the coding epoch was defined as 5 minutes from the start or once a child who was speaking at the 5-minute mark completed their sentence. I developed a novel coding scheme to capture children's overall engagement and conversational utterances focused on self (vs. other) referential information and positively (vs. negatively) valenced information about themselves. See Figure 11 for summary of the coding steps and categories. See Appendix D for code definitions and full details of the coding scheme.



Level	Code	Description
1	**Change Topic**	Any new conversation topic initiated.
	Continue Topic	Any form of continued conversation. May result from one dyad asking a related question, or from natural conversation continuity.
2	**Self**	Mostly occurred following a Share – the speaker shares something related to themselves.
3	Personal Self	A statement directly related to the speaker.
4	Trait	A thought, feeling, preference, desire, physical or personality trait.
5	Positive	An explicit positive word expressed (ex. "Love"; "Awesome")
	Negative	An explicit negative word expressed (ex. "Hate"; "annoying")
	Neutral	No explicitly stated positive or negative word, or if both were mentioned at the same time (ex. "My brother is *annoying,* but I *love* him."
4	Fact	An anecdote, something they have done, or a statement about a close other (i.e., parent, sibling, friend, teacher; ex. "My mother's name is…..").
5	Positive	An explicit positive word expressed.
	Negative	An explicit negative word expressed.
	Neutral	No explicitly stated positive or negative word, or if both were mentioned at the same time.
3	Declarative Self	Something related to the state of the world – for example, the speaker discussing the size of their school.
2	**Other**	Mostly occurred following a Seek – the speaker asks something related to the other participant.
3	Personal Other	A thought, feeling, preference, desire, physical or personality trait.
	Declarative Other	Something related to the state of the world – for example, the speaker asking about the size of the other participant's school.
6	**Open**	Mostly occurred prior to/following a continue topic. Allowing the conversation to continue via a prompt, or natural conversation continuity.
	Closed	Mostly occurred prior to/following a change topic. Stopping the conversation from continuing via an abrupt statement with no prompt, or natural conversation continuity.

Figure 11. Summary of Coding Scheme

(Left) A visual representation of the coding scheme. Each "level" number corresponds to descriptions presented in the table (right).

The goal of the present study was to quantify engagement and the self-referential and positivity biases in children's conversational utterances. Thus, I focused on utterances that included (1) sharing **self**-referential and seeking information about the **other** at Level 2; (2) sharing information about personal **traits;** (3) sharing **emotional** information; and (4) having an **open** conversational style. All participants were included in analyses regardless of the frequency with which they spoke. To account for differences in total amounts of talking between participants, all frequency codes were converted into proportion scores: each individual code within a Level (e.g., self and other; Level Two) was divided by the total number of codes within the Level (e.g., self/ self+other or Level Two total; 509/831; other/Level two total; 322/831). Any code that captured fewer than 15% of the total utterances was excluded from further analysis. Thus, due to the low frequencies of *declarative* codes (see Table 7), it was not possible to achieve acceptable inter-rater reliability, and this code was dropped from subsequent analysis. Additionally, while the frequencies of *positive* (14.29%; 71/497) and *negative* (8.85%; 44/497) statements were low, due to the theorized importance of these codes, they were retained, but combined to reflect the total frequency of *Emotionally Valenced Content*. AH trained one undergraduate research assistant on the implementation of the coding scheme. Inter-rater reliability was assessed using Cohens Kappa and resulted in moderate to excellent reliability estimates (Landis & Kock, 1977) across all codes of interest based on double coding of 30% (n= 13 dyads/26 children) of cases (see Table 7).

Table 7. Summary of code frequencies, proportions, and inter-rater reliability. For detailed description of coding scheme, see Appendix D.

Code Level	Level Frequency	Individual Code	Code Frequency	Code Proportion	K
1. Topic	831	Change	246	29.60%	.890
		Continue	585	70.39%	
2. Referent	831	Self	513	61.73%	.958
		Other	318	38.26%	
3a. Self-Content	513	Personal	497	84.91%	.515
		Declarative	16	~~3.12%~~ Dropped	
3b. Other-Content	318	Personal	278	87.42%	.672
		Declarative	40	~~12.58%~~ Dropped	
4. Self-Topic	497	Trait	185	37.22%	.740
		Fact	312	62.77%	
5. Self-Valence	497	Positive	71	14.29% Combined	.800
		Negative	44	8.85%	
		Neutral	382	76.86%	
6a. Self Function	513	Open	425	82.85%	.500
		Closed	88	17.15%	
6b. Other Function	318	Open	171	53.77%	.527
		Closed	147	46.22%	

Data Reduction: Principal Component Analysis.

For the purposes of data reduction, a principal components analysis (PCA) using SPSS Statistics 22 was conducted with the four proportion scores of interest. Correlations revealed that the proportions of sharing **self**-relevant information were positively correlated with the proportion of sharing **trait** information and having an **open** conversational style. Sharing **trait** information, **emotional** information, and having an **open** conversational style were all significantly and positively correlated with one another (Table 8). The Kaiser-Meyer-Olkin measure of sampling adequacy was .55, Bartletts test of sphericity was significant, X^2 (6) = 95.92, p < .001, and the communalities were all above .68, confirming that each item shared common variance with each of the other items. Thus, the minimum requirements for conducting a PCA analysis were met (Williams et al., 2010).

Initial eigenvalues revealed two components with values greater than 1, which accounted for 60% and 29% of the variance, respectively (Table 8). Solutions for the factors were examined using varimax rotation with Kaiser normalization. Component 1 was comprised of the proportion of Emotional (.960) and Trait (.914) statements and Component 2 was comprised of the proportion of Self (.920) and Open (.905) statements. None of the indicators cross-loaded on the components. Thus, composite scores were created for Component 1, hereafter the *Social-Engagement* composite score, with higher scores reflecting sharing self-referential information and maintaining an open conversational style. Component 2, hereafter *Self-Disclosure*, was also created, with higher scores reflecting sharing personal traits and emotionally-valenced topics. The *Self-Disclosure* composite score was slightly left-skewed, and the *Social-Engagement* composite score was slightly right skewed. However, both composite scores were within an acceptable range of skewness and kurtosis (-2 to +2; Kim, 2013).

Table 8. Summary of correlations and composite scores for the codes of interest.

<table>
<tr><th colspan="8">Correlation Summary</th></tr>
<tr><td>Variable</td><td colspan="2">Mean (%)</td><td>Standard Deviation</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>1. Self</td><td colspan="2">51.70</td><td>29.39</td><td>-</td><td></td><td></td><td></td></tr>
<tr><td>2. Trait</td><td colspan="2">31.32</td><td>26.92</td><td>.41**</td><td>-</td><td></td><td></td></tr>
<tr><td>3. Emotion</td><td colspan="2">20.08</td><td>23.90</td><td>.21</td><td>.82**</td><td>-</td><td></td></tr>
<tr><td>4. Open</td><td colspan="2">70.89</td><td>36.76</td><td>.72**</td><td>.38*</td><td>.27*</td><td>-</td></tr>
<tr><td colspan="8">*Significant at <.05
**Significant at <.01</td></tr>
<tr><th colspan="8">PCA Summary</th></tr>
<tr><th>Composite Score</th><th colspan="2">No. of items</th><th>Proportion Range</th><th>Cronbachs α</th><th>Composite M (SD)</th><th>Composite Skewness</th><th>Composite Kurtosis</th></tr>
<tr><td rowspan="2">Self-Disclosure</td><td rowspan="2">2</td><td>Emotion</td><td>0.00, 1.00</td><td rowspan="2">.826</td><td rowspan="2">.257 (.242)</td><td rowspan="2">.968</td><td rowspan="2">.552</td></tr>
<tr><td>Trait</td><td>0.00, 1.00</td></tr>
<tr><td rowspan="2">Social-Engagement</td><td rowspan="2">2</td><td>Self</td><td>0.00, 1.00</td><td rowspan="2">.898</td><td rowspan="2">.613 (.307)</td><td rowspan="2">-1.17</td><td rowspan="2">.037</td></tr>
<tr><td>Open</td><td>0.00, 1.00</td></tr>
</table>

4.2.4 Data Analysis Plan

Self-Disclosure and Social-Engagement scores (the composite scores from the PCA analysis; Table 8) were regressed onto self-reported surgency and EC (Hypothesis 1a and 1b). The self-referential ERP bias and the positivity recall and memory sensitivity bias scores were then regressed onto surgency and EC, respectively (Hypothesis 2a and 2b). Self-Disclosure and Social-Engagement scores were then regressed onto the self-referential and positivity biases scores (Hypothesis 3a and 3b). Finally, a multi-staged mediation model was planned to test the overall hypothesis that children's SRET performance would partially mediate the relation between temperament and Self-Disclosure and Social-Engagement (Hypothesis 4). Exploratory correlations between age and gender with each of the factors of interest are presented in Appendix E, table E1.

4.3 Results.

Hypothesis 1: Associations between Self-Reported Temperament and Self-Disclosure and Social-Engagement.

It was predicted that higher self-reported (a) surgency and (b) EC would be positively associated with Self-Disclosure and Social-Engagement composite scores.

(a) Surgency was not associated with Social Engagement, $R^2 = .000$, $F(1,56) = .003$, $p = .959$, or Self Disclosure, $R^2 = .008$, $F(1,56) = .468$, $p = .497$, (see Table 9).
(b) Likewise, effortful control was not associated with Social Engagement, $R^2 = .025$, $F(1,60) = 1.53$, $p = .220$, or Self Disclosure $R^2 = .005$, $F(1,60) = .321$, $p = .573$ (see Table 9).

Table 9. Coefficients of regression analysis examining self-reported temperament on composite scores of conversational style.

	Surgency and Social Engagement				
Predictors	B	SE	β	*t*	*p*
Constant	.230	.135		1.71	.094
Surgency	.002	.043	.007	.051	.959
	Surgency and Self Disclosure				
	B	SE	β	*t*	*p*
Constant	.503	.185		2.72	.009
Surgency	.040	.058	.091	.684	.497
	Effortful Control and Social Engagement				
	B	SE	β	*t*	*p*
Constant	.003	.195		.014	.989
Effortful Control	.069	.056	.158	1.24	.220
	Effortful Control and Self-Disclosure				
	B	SE	β	*t*	*p*
Constant	.464	.261		1.78	.080
Effortful Control	.042	.075	.073	.567	.573

Hypothesis 2: Associations between Temperament and Social Information Processing Biases.

It was predicted that (a) surgency would be positively associated with enhanced ERP amplitudes following self- compared to other-referential stimuli, and (b) EC would be associated with increased memory for positive relative to negative information

(a) Surgency was not significantly associated with the difference in ERP amplitudes during the encoding of Self relative to Other referential trait adjectives, $R^2 = .000$, $F(1,44) = .001$, $p = .978$, (see Table 10).

Table 10. Coefficients of regression analysis examined self-reported surgency on the self-referential bias across ERPs.

	Surgency and the Self-Referential processing bias (ERP amplitude)				
Predictors	B	SE	β	*T*	*P*
Constant	.978	1.62		.604	.549
Surgency	.015	.527	.004	.028	.978

(b) Effortful control was positively associated with the magnitude of positivity bias as indexed by recall, $R^2 = .070$, $F(1,60) = 4.49$, $p = .038$ (Figure 12), but not as indexed by memory sensitivity, $R^2 = .035$, $F(1,60) = 2.15$, $p = .148$ (Table 11).

Table 11. Coefficients of regression analysis examining self-reported EC on the positivity bias across memory.

	Effortful Control and the Positivity bias across Recall				
	B	SE	β	*t*	*p*
Constant	-4.41	2.50		-1.77	.082
Effortful Control	1.51	.714	.264	2.12	.038*
	Effortful Control and the Positivity bias across Memory Sensitivity				
	B	SE	β	*t*	*p*
Constant	-.404	.356		-1.14	.261
Effortful Control	.149	.102	.186	1.47	.148

Hypothesis 3: Associations between Social information processing biases and Self-Disclosure and Social-Engagement.

It was predicted that stronger (a) self-referential (ERP) and (b) positivity (memory) biases would be positively associated with Self-Disclosure and Social-Engagement.

(a) The self-referential bias across ERP scores was not associated with observed Self-Disclosure, $R^2 = .063$, $F(1,47) = 3.19$, $p = .081$, nor with Social Engagement , $R^2 = .000$, $F(1,47) = .007$, $p = .935$ (see Table 12).

Table 12. Coefficients of regression analysis examining the self-referential bias on Self-Disclosure and Social-Engagement composite scores.

	Self Referencing bias and conversational style				
Predictors	B	SE	β	*t*	*p*
Constant	.218	.034		6.32	<.001
Social Engagement	-.001	.013	-.012	-.082	.935
Constant	.	.051		12.21	<.001
Self-Disclosure	-.034	.019	-.252	-1.79	.081

(b) The positivity bias as indexed by memory recall was unrelated to Social Engagement, R^2 =.001, $F(1,60) = .031$, $p = .860$, or Self-Disclosure, $R^2 = .005$, $F(1,60) = .291$, $p = .591$ (see table 13). Likewise, the positivity bias as indexed by memory sensitivity was not associated with Social Engagement, $R^2 = .004$, $F(1,60) = .247$, $p = .621$, or Self-Disclosure, $R^2 = .018$, $F(1,60) = 1.11$, $p = .297$ (see Table 13).

Table 13. Coefficients of regression analysis examining the positivity-bias on Self-Disclosure and Social-Engagement composite scores.

	Positivity bias across Recall and conversational style				
Predictors	B	SE	β	*t*	*p*
Constant	.243	.032		7.71	<.001
Social Engagement	-.002	.010	-.023	-.177	.860
Constant	.616	.042		14.80	<.001
Self-Disclosure	-.007	.013	-.070	-.540	.591
	Positivity bias across Memory Sensitivity and conversational style				
	B	SE	β	*t*	*p*
Constant	.246	.031		7.82	<.001
Social Engagement	-.035	.070	-.064	-.497	.621
Constant	.599	.041		14.52	<.001
Self-Disclosure	.097	.092	.135	1.05	.297

Hypothesis 4: Mediation analyses.

Mediations were run to examine any potential indirect effects of each temperament attribute (surgency and EC) on Self-Disclosure and Social-Engagement using model 4 in the PROCESS macro of SPSS. However, there was no statistical evidence for indirect effects (see Appendix E, table E2 for summary of regression effects).

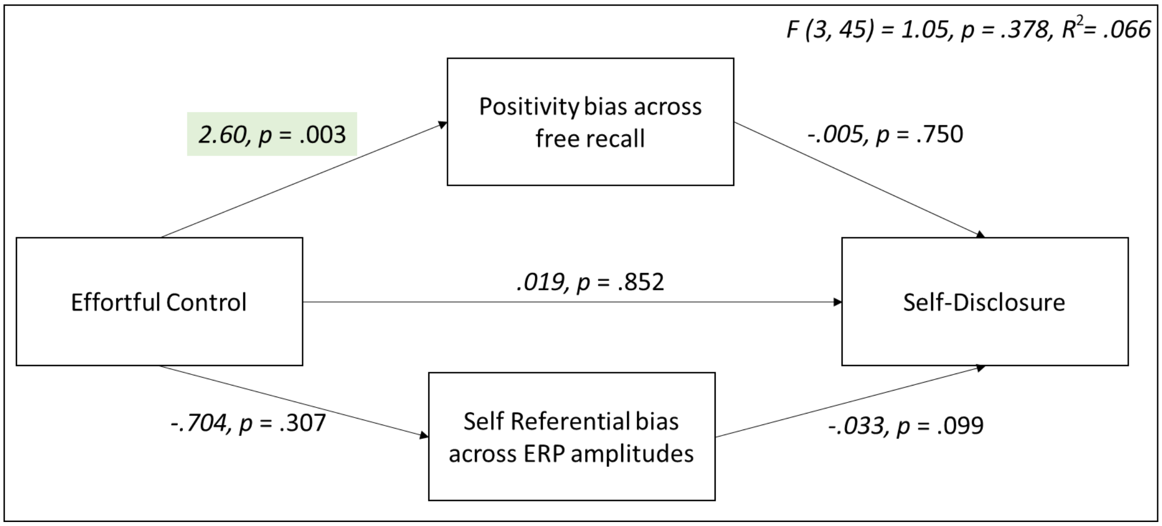


Figure 12. Summary of mediation effect.

Standardized regression coefficients for the simplified summary model demonstrating a significant association only between EC and the positivity bias in free recall memory (highlighted). There were no indirect effects found in the mediation models outside of the regression analyses performed in section 4 (recall: β = -014 [-.090, .066]; self-referential ERP: β = .024 [-.014, .090]). See Appendix E, table E2 for mediation summaries of all tests.

4.3.1 Results Summary.

Neither surgency nor EC were associated with either conversational style. However, EC was associated with improved memory for positive relative to negative information across the SRET. No other associations were found.

4.4 Discussion

The goal of this exploratory study was to examine the inter-relations between temperament, the self-referential and positivity biases, and children's conversational style during an initial interaction with an unfamiliar peer. In the end, few of the hypotheses were supported. Neither self-reported surgency or EC were associated with children's conversational styles; neither the self-referential or positivity-biases were associated with conversational styles; and children's surgency was unrelated to the magnitude of their self-referential biases on the SRET. The only hypothesis that was supported was that of an association between higher self-reported EC and improved recall memory for positive relative to negative trait adjectives from the SRET (Chapter 3). The overall lack of support for most of our hypotheses was likely a result of being underpowered as a result of the need to end data collection early due to COVID-19 restrictions. The sample size is the most obvious limitation of our study and prohibited me from conducting potentially more sensitive dyadic level analyses to account for dependencies between partners' social behaviours (i.e., if one partner shared a lot of personal information did their partner tend to do so as well?). Despite this limitation, I believe this is an interesting and important area of research with methodological implications for studying the inter-relations among temperament, information processing biases, and conversational style in childhood.

I designed a novel coding scheme to characterize the content of children's spontaneous vocalizations during an initial conversation with an unfamiliar peer. The goal was to capture social engagement, and topics which mapped onto the self-referential and positivity-biases from the SRET (Chapter 3). While a small sample (eight children; four dyads) did not engage in *any* vocalizations during the 5-minute interaction, descriptive data revealed that most children shared information about themselves that was neutral and factual (e.g., "I have a pet cat"; "I have 2 older sisters"; "I am in grade 6"), rather than emotional and personal (e.g., "I really like playing soccer"; "I am scared of roller coasters"). Children also worked to maintain a conversation where similar interests were identified, as indexed across their relatively high proportion of 'continue' (70%) compared to 'change' (30%) proportion scores (Table 7; e.g., Child A: "I have two sisters"; Child B: "I also have two sisters, are they older or younger?"; Child A: "One is older, and one is younger, how about you?"). The patterns of inter-relations among the conversational styles supported the creation of two independent composite scores dimensions: Social Engagement (increased sharing of self-referential information in an open conversational style) and Self-Disclosure (increased sharing of emotional and personal details). Interestingly, these composites map on to past studies relying on broad informant report measures of social competence that include social initiative (attempts to engage in social interactions); social reciprocity (maintaining conversational back-and-forth); and self-monitoring (modifying one's social behaviour to accommodate the interaction; for review, see Harchik, Sherman, & Sheldon 1992). The similar behaviour identification highlighted by the present study and the decades-old research using parent/teacher reports suggests that the present coding scheme is valid for examining individual conversational styles in children.

However, contrary to my hypothesis and the extensive literature supporting an association between temperament and social competence (for review, see Semrud-Clikeman 2007), neither self-reported surgency or EC was associated with children's conversational styles. While it seems unlikely that children's styles of approaching and navigating moment-to-moment conversations does not tap into their temperamental surgency and EC abilities, it may be that the study parameters (i.e., sample size, brief interaction length) were not sensitive enough to identify these associations. By mid-to-late childhood, children may have social scripts which aid them in initiating social interactions with a new peer (e.g., from *personal other* codes, "How old are you?"; "Do you have any siblings?"; "What school do you go to?"; "Do you have any pets?"). It is possible that as an interaction continues, social scripts will be exhausted at which point children need to generate novel ideas/topics for discussion. It may be at this point (i.e., beyond the first five minutes of getting to know someone) that temperamental differences become more apparent. Moving beyond the first five minutes of conversation may also reveal increased proportions of positive and negative statements as individuals become more acquainted with each other, thereby allowing us to make a more direct examination of the positivity-bias in children's conversational style. The decision to combine the positive and negative codes into a single 'emotional' code occurred post-hoc due to an overall low number of positive and negative statements said. Therefore, we were unable to capture the specifics of valence within this conversational time frame (i.e., create a meaningful positive-negative difference score for each participant). It is also possible that temperament relates to more global social tendencies or the tendency to display different non-verbal social cues (i.e., facial expressions, eye contact) during the initial stages of a social interaction. For example, instead of vocalizations, surgency may be associated with the display of social engagement and positive affect (i.e., eye-contact, smiling), given its association with approach motivation and high intensity pleasure. Additionally, EC may be associated with the ability to continue or change a conversation topic to respond to a peer's interests, given the association with EC and cognitive flexibility and perspective taking.

While we expected temperamental surgency to be associated with a heightened attention to self- compared to other-referential cues across children's LPP during the SRET (Chapter 3), this was not the case. The lack of effect in the present study may be due to the use of the broad band factor of surgency, which is made up of three specific dimensions (i.e., high intensity pleasure, reverse scored fear, and reverse scored shyness). It is therefore possible that this broad band factor does not sufficiently capture the fine-grained associations between temperament and attention elicited by a self-referential cue, and instead one of the dimensions (e.g., shyness) or aspects of affiliation (see Section 5.3) may be better associated with attention and conversational style.

Finally, as expected, increased EC was associated with enhanced recall memory for positive compared to negative trait adjectives, regardless of the referent of the information. EC is associated with cognitive flexibility (Quiñones-Camacho et al., 2019; Rothbart & Rueda, 2005) and affective memory consolidation (Rothbart & Rueda, 2005). Thus, it was expected that high EC would contribute to the improved memory performance for positive relative to negative information in normative development. This association may be central to the explanation of why high EC is found to be protective against the development of internalizing and externalizing disorders in childhood and adolescence (Ahmed et al., 2015; Friedman & Robbins, 2021; see section 5.3 for more details).

We acknowledge that the correlations presented in the current study are not the entire story of how temperament and social information processing biases impact social development (for review, see

Sanson et al., 2004). The present study did not consider distal influences on development, including socioeconomic status, family structure and relationships, community or extracurricular involvements, or school performance, just to name a few (i.e., the Bronfenbrenner Ecological Systems theory; Härkönen, 2007; Vélez-Agosto et al., 2017). All these additional factors are known to play a role in child social development (Sanson et al., 2004; Vélez-Agosto et al., 2017). Moreover, the correlations in this study are cross-sectional and the direction of effects cannot be determined. To demonstrate the role of outside influences on development, as well as the directionality of effects, future studies will need to employ a longitudinal design tracking children across childhood and adolescence. Such a design would allow for an examination of the possibility of bidirectional effects where social interaction styles might, over time, impact self-referential and positivity biases. Despite the limitations, the present study is the first of its kind to test whether these specific cognitive biases mediate the relationship between temperament and observed social behaviours in late childhood.

Chapter 5: General Discussion

I presented three studies which explored patterns of attentional biases towards self-referential and positive information across neural and behavioural encoding, subsequent memory, and conversational style. My goals were to address how the self-referential and positivity biases modulate neural encoding and subsequent memory in adults and children, and how individual differences in these biases are associated with children's styles of interacting with unfamiliar peers. To do so, I examined how self- compared to other-referential contextual primes modulate adults' attention during the encoding of neutral faces. I also examined how the attentional differences following self-referential cues influence incidental memory for contextual information (Chapter 2). I then sought to examine whether children display similar self-referential and positivity-biases to those of adults in their neural encoding and subsequent memory of trait adjectives presented in a self- compared to other-referential context (Chapter 3). In these two chapters, I demonstrated that both adults and children display increased sustained attention (as indexed by larger LPP amplitudes) for stimuli presented in a self- compared to other-referential context. In adults, the increased attention at encoding amplified subjective ratings and arousal for neutral faces, and improved incidental memory for self-referential contextual information. In children, there was a tendency to preferentially recall positive information regardless of the referent, however, memory performance was dependent on task parameters such as referent order. Finally, I conducted an exploratory study to examine the associations between individual differences in children's temperament, attention biases, and conversational styles during a live interaction with an unfamiliar peer (Chapter 4). This unique study revealed an association between children's effortful control and their positivity-bias in memory and offers a foundation for exploring the functional significance of the self-referential and positivity-biases for everyday behaviour.

In this final chapter of my dissertation, I will (1) discuss the robustness of self-referential effects on the LPP waveform, (2) question the role of the positivity-bias in sustained attention but argue for its relevance in behaviour and memory consolidation and retrieval, and (3) discuss the implications of the self-referential and positivity-biases in supporting social behaviour and development. Within these discussions, I will also revisit the conceptual models I presented in Chapter 1 based on the findings from my empirical chapters.

5.1 The Self-Referential Bias, Sustained Attention, and Memory.

In Chapters 2 and 3, I found evidence for the self-referential bias across neural encoding (the LPP) in two different tasks and populations, suggesting a generalizable effect of self-referential cues on sustained attention. However, when considering these results in the context of the extant literature, the onset and duration of the self-referential effect across the LPP appear impacted by task parameters. In response to trait adjectives primed by self- and other-referential contexts in adults, the onset of the LPP is impacted by the design of the trial progression (i.e., trait adjectives presented in self vs. other referent blocks; trait adjectives presented with self- vs. other-referential trials mixed within the same block; Hudson et al., 2020). In blocked designs, the self-referential effect occurred between 400-800ms, while it occurred between 600-800ms for mixed-referent designs. Hudson and colleagues (2020) interpreted these differences to reflect the impact of trial types (blocked versus mixed) on sustained attention. Task modulations on the self-referential effect on the LPP are also found in studies examining neutral faces primed with self and other referential social statements (i.e., 220-350ms, 400-500ms and 700-1000ms, Klein et al., 2015; 400-600ms, Wieser et al., 2014; 150ms-750ms McCrackin & Itier, 2018). It is currently unclear whether these differences in the LPP effect are a result of i) the number or specifics of the face stimuli used (22 in Klein et al., 2015; 8 in McCrackin & Itier, 2018; 36 in Wieser et al., 2014); ii) the trait adjectives embedded within the contextual primes and their overall number and repetitions (18 in Klein et al., 2015; 156 in McCrackin & Itier, 2018; 36 in Wieser et al., 2014); iii) the sentence structure and themes across studies (neutral, physically threatening and socially threatening in Klein et al., 2015; positive and negative, targeting social competence, physical attractiveness, and signs of anxiety, in McCrackin & Itier, 2018; positive, negative, or neutral in Wieser et al., 2014); or iv) the data analysis approach (specific time windows and electrodes targeted). To determine what aspects of the task modulate the LPP, future work must examine task variations using within-subjects designs. Understanding what aspects modulate the onset and duration of the LPP may have implications for learning, memory, and arousal which may influence emotion regulation and the interpretation of subsequent stimuli (MacNamara et al., 2022). However, what these data do suggest is that sustained attention for information primed by self-referential cues, as reflected by the LPP, is apparent in different designs, with task demands modulating the temporal dynamics of the effect in adults.

Interestingly, in my sample of children (Chapter 3), the self-referential effect on the LPP occurred between 400-800ms using a blocked referent design, which is a time interval similar to that reported by Hudson and colleagues (2020) in their blocked design study with adults. An interesting future direction will be to examine whether the self-referential effect on the children's LPP is also modulated by task design (i.e., blocked versus mixed trial design), which would suggest that sustained attention to self-referential cues in childhood is also influenced by task demands. To further examine the developmental progression of the timing of self-referential processing, future work needs to examine whether adolescents are similarly impacted by study design and task parameters. Despite the heightened emphasis on social relationships in adolescence, as far as I know this age range (13-20) has not been the focus of any ERP studies examining self- compared to other-referential cues. It is therefore unclear when the timing and amplitude of self-referential processing across ERPs becomes adult-like, and if and when between 13-20 years old this effect may peak. Given the hyper-focus on self-referential processing and social comparisons during this developmental period, the self-referential effect may be more resistant to influences of task effects, but more influenced by individual differences in trait anxiety. For example, Schwarz and colleagues (2013) found that adults who reported higher fear of negative evaluations on the BFNE (Leary, 1983) – a scale that indexes fear or tolerance of how others view them – showed enhanced neural activation for neutral faces primed with self-negative social evaluative statements. While this study was in adults, the results suggest that self-referential processing is influenced by individual differences in social anxiety, and it is possible that the relative impact of these differences vary across developmental stages (see section 5.3 for more details).

While both adults and children displayed a self-relevance effect across the LPP during stimulus encoding, they differed in their subsequent memory performance. Adults showed improved recognition memory and memory accuracy for self-referential contextual information (Chapter 2) while children did not (Chapter 3). This lack of self-referential effect in children's memory is inconsistent with findings demonstrating improved memory for isolated trait-adjectives presented in self- compared to other-referential contexts in adults (Hudson et al., 2020; Pereira et al., 2021; Symons & Johnson, 1997) and in children (Burrows et al., 2017; Henderson et al., 2009). It is likely that this lack of self-relevance effect on memory in Chapter 3 is a result of the overall memory demands of the task as past studies that found an effect in children used fewer trials (64 words in Chapter 3 relative to 42 words in other child SRET paradigms, i.e., Burrows et al., 2017; Henderson et al., 2009). The reason for using more words than previous studies in Chapter 3 was to ensure I had enough trials for the ERP analysis, resulting in a trade-off between the number of trials needed, and the capacity of children's memory. This was the first study to examine children's ERPs to positive and negative trait adjectives in self- and other-referential conditions, and now future work should focus on either the ERP or memory aspect of this task instead of attempting to examine them together, as I did here.

Regardless of how and why memory differed between adults and children in my thesis, these mixed memory results suggest that the self-referential bias at encoding is not perfectly coupled with the self-referential bias in memory. Therefore, it is likely that there are different processes operating at encoding and during memory storage or retrieval, with sustained attention at encoding being necessary but not sufficient to enhance memory performance. Consequently, I have revised my model from Chapter 1 to reflect two different biases: one at encoding (reflected in neural and behaviour outcomes), and one at memory (Figure 13).

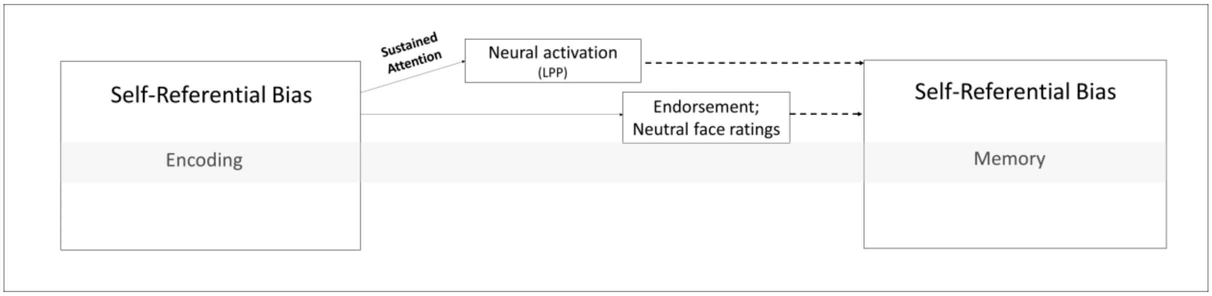


Figure 13. Sustained attention and memory following self-referential cues

The sustained attention following a self-referential cue is reflected by enhanced LPP amplitudes in adults and children during information encoding, however, the timing of the effect is modulated by task parameters in adults. Regardless of potential task influences, the enhanced attention at encoding modulates in-lab behaviour (i.e., endorsement; neutral face ratings) and improves memory (i.e., behavioural recall; recognition); however, my data suggest that memory effects are also constrained by task parameters. Therefore, sustained attention at encoding is necessary but not sufficient for memory performance. The solid black arrows represent the associations supported by the results in this thesis, whereas the dotted black lines represent the hypothesized associations that were not directly tested (i.e., neural activation to memory) or not consistently supported (i.e., self-referential bias in memory).

The differences in memory performance between adults and children following self-referential cues prompts the consideration of other ways in which development impacts referent processing. Previous behavioural studies demonstrated that children have a basic representation of the self as distinct from others within the first year of life (Lewis, 2003). Around 18 months, children show signs of self-awareness in the classic mirror mark test (Lewis et al., 1989), which precedes the ability to refer to themselves in language (Courage et al., 2004; Lewis & Ramsay, 2004), suggesting that self-recognition is the precursor to the use of personal pronouns. Eventually 3- to 4-year-old children develop the understanding that others have different mental states than oneself, an ability referred to as Theory of Mind (ToM; Premack & Woodruff, 1978). With the understanding that others have different mental states, and are therefore able to make judgements about them, children develop self-conscious emotions (e.g., embarrassment) and display strong ownership over items that belong to themselves rather than those that belong to others (Ross et al., 2011). However, it is not until around the age of 10 that children describe themselves in relation to others with a similar complexity to that of adults (Pfeifer et al., 2007). During this phase of development (i.e., 7-11 years), memory performance for self- compared to other-referential trait adjectives increases gradually over time (Halpin et al., 1984; Hammen & Zupan, 1984;

Ray et al., 2009). This increased memory for self- compared to other-referential information is thought to reflect a strengthening of one's self-concept (Halpin et al., 1984) and the individuation of oneself from others (Ray et al., 2009). Together, these studies demonstrate that understanding the self is apparent in early childhood and sets the stage for the gradual development of meta-cognitive abilities involving ToM. In support of the association between self-referential development and ToM, recent work in adults demonstrates a positive association between individual differences in self-referential memory capacity and ToM (Dinulescu et al., 2021). Specifically, improved recognition memory for adjectives processed relative to the self (e.g., "does this word describe you?"), versus a fictional other (e.g., "does this word describe Harry Potter?") or in terms of physical parameters (e.g., "is this word in uppercase or lowercase letters?") was positively associated with accuracy in judging how others are feeling (the Reading the Mind in the Eyes Task; RMET; Baron-Cohen et al., 2001), and with empathic accuracy, which describes the process of understanding and sharing others' emotions (Preckel et al., 2018). What remains unclear, however, is the developmental progression of the relationship between self-referential processing as indexed by the LPP and by memory performance, and ToM development. This relation may or may not be critical for social development (see section 5.3 for further discussion), and consequently warrants examination across different age ranges while using age-appropriate ToM tasks.

5.2 The Positivity-Bias in Behaviour and Memory.

In contrast to the self-referential bias, I found no evidence for a positivity-bias across the LPP in either adults or children, which questions the generalizability of the positivity-bias found in past studies. Previous studies demonstrating a positivity bias across adult ERPs during the encoding of isolated trait adjectives were limited in that they only presented a single referent (i.e., self) condition (e.g., Auerbach et al., 2015). However, the positivity-bias across ERPs is not found as reliably when an other-referent condition is included for comparison (Hudson et al., 2020; Pereira et al., 2021; Shestyuk & Deldin, 2010). These mixed results of valence across trait adjective encoding in a single- compared to multi-referent paradigm again suggest that task parameters directly modulate attention. Specifically, Hudson and colleagues (2020) found an effect of valence on the LPP in a mixed-referent design, but not a blocked-referent design, while the opposite would be expected if processing one referent at a time increased the salience of valence cues during encoding. Future work will need to address these paradigm effects using within-subjects designs to clarify under which self-referential processing contexts valence cues influence sustained attention.

Mixed evidence for the positivity-bias at encoding is also apparent with neutral faces. For example, Klein and colleagues (2015) found enhanced LPP amplitudes for neutral faces primed by negative social statements regardless of referent, while McCrackin and Itier (2018) found enhanced ERP amplitudes for neutral faces primed by positive self-referential social statements. When using robust mass univariate statistics (MUS) in Chapter 2, I did not find any effect of valence, questioning the reliability of valence effects previously reported. More ERP studies using robust MUS are necessary to elucidate valence effects on the LPP in face priming paradigms.

Despite the lack of valence effects on the LPP, I did find valence effects across behaviour (Figure 14). In Chapter 2, adults demonstrated enhanced arousal ratings to neutral faces primed by negative social statements (particularly when these were self-relevant), as well as improved recognition memory for negative relative to positive social statements regardless of referent. These behavioural results may point to a negativity bias in adults, particularly in response to social threat (i.e., someone is saying something negative about you). While my study was not intended to capture a negativity bias, and my results may be particular to my sample only (i.e., not generalizable), future work should more directly examine the role of social threat and the existence of a negativity bias in adults, as this may reflect a normative bias for identifying and remembering threatening individuals. For example, in a separate line of research, the LPP amplitude to neutral faces was amplified during encoding and during a recognition period when that face was paired with a threatening conditioned stimulus during the learning phase (i.e., an electric shock; Ferreira de Sá et al., 2019). This was interpreted to reflect a ‘memory trace’ for threatening individuals captured across the LPP. If a ‘memory trace’ is indexed by the LPP during the recognition of threatening social stimuli, perhaps we would find an enhanced LPP response to neutral faces during a subsequent recognition phase if they were primed with negative relative to positive social evaluative statements during encoding (i.e., replication of Chapter 2 with an additional face recognition phase). In general, given the overall mixed findings of valence cues on both neural encoding and memory performance, future work needs to examine under what contexts (and with which stimulus type, and what populations) a positive or negative bias appears during encoding and memory, as this may highlight processes that are critical for adaptive social functioning.

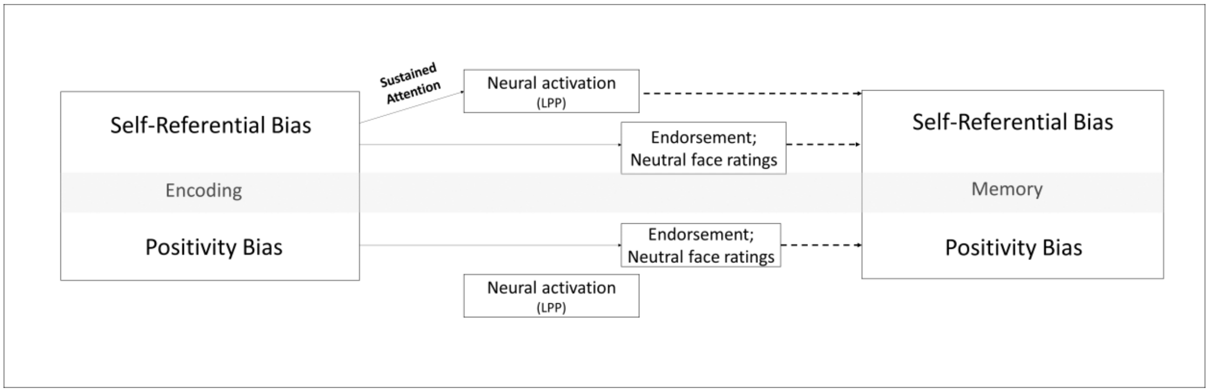


Figure 14. The malleability of the positivity bias at encoding and memory.

I found no evidence for a consistent positivity bias on the LPP amplitude (i.e., on sustained attention) in adults or children. Additionally, the specific task used modulated the type of behavioural response elicited by the paradigm. However, children showed enhanced recall memory for positive trait adjectives (regardless of the referent), potentially reflecting regulatory control mechanisms ensuring that positive rather than negative information is stored into long term memory. However, this recall effect disappeared when block order was considered (dotted black line). These mixed results across neural encoding, task behaviours, and memory suggest that responses to valence are highly malleable, questioning the reliability of the "positivity-bias".

In interpreting my own data from Chapter 3, I assumed that regulatory processes took place during the consolidation of information, but it is possible that it occurred during the memory retrieval process (or during both). A recent study examining ERPs during the recognition task of the SRET suggested that negative self-relevant trait adjectives may be actively suppressed during the retrieval process (Pereira et al., 2021). Pereira and colleagues (2021) found no evidence of enhanced ERPs during the encoding of positive or negative trait adjectives but found enhanced LPP amplitudes for old negative (compared to new negative and old/new positive) trait-adjectives during the recognition test, despite behavioural performance for negative trait adjectives being impaired. The lack of valence effect at trait adjective encoding was interpreted in a similar vain to my interpretation here: that task effects (i.e., intentional versus incidental learning instructions; adjective arousal; see discussion on p. 32 in Chapter 2) influence ERP responses to stimulus encoding (Pereira et al., 2021). However, the enhanced LPP amplitude when recognizing previously viewed negative self-referential trait adjectives, yet impaired behavioural memory performance for negative relative to positive trait-adjectives (i.e., the positivity bias in memory), was interpreted to reflect an engagement of post-retrieval monitoring resources for negative self-referential words (Pereira et al. 2021). In the context of my work, this 'monitoring resource' may reflect regulatory control actively suppressing negative information during memory retrieval in Chapter 3. Indeed, in Chapter 4 I found that effortful control (EC; Figure 15) was positively associated with the magnitude of children's positivity bias in memory. EC describes the ability to flexibly guide attention to promote goal directed behaviour (Rothbart et al., 2000). Therefore, I interpret the results from Pereira and colleagues (2021) and Chapter 4 to reflect regulatory control in ensuring that positive relative to negative trait adjectives from the SRET are prioritized in memory, either during storage in long-term memory, or during memory retrieval processes.

The lack of support for a positivity-bias across ERPs at encoding is not to say that valence processing is not important for social cognition or during encoding processes. Indeed, there is a large literature demonstrating that individual differences in the magnitude of a positivity-bias at encoding are associated with the protection against, or development of, internalizing disorders such as anxiety and depression (Beer, 2014). Behaviourally, children in Chapter 3 did endorse (said "Yes" to) more positive than negative trait adjectives regardless of whether they considered the adjectives relative to themselves or to a well-known (previously validated) neutral fictional character. This pattern of enhanced endorsement of positive self-referential trait adjectives replicates many previous studies with heathy adults and children (Auerbach et al., 2015, 2016; Burrows et al., 2017; Hudson et al., 2020; Pereira et al., 2021a; Rogers et al., 1979; Shestyuk & Deldin, 2010; Watson et al., 2007). Therefore, a positivity-bias does appear relevant during trait adjective endorsement, although this does not translate to enhanced sustained attention at encoding as indexed by the LPP in children (Chapter 3) nor reliably in adults. However, there does appear to be developmental differences in the behavioural endorsement of valence cues (for review, see Mezulis, 2004), such that adolescents between 15-17 years old peak in their negative self-judgements (i.e., endorsement of negative self-referential cues), which decreases in early adulthood (Carstensen & DeLiema, 2018; McArthur et al., 2019; van der Cruijsen et al., 2018). Additionally, recent work has demonstrated that in females, the endorsement of negative self-relevant adjectives increased between 11-19 years, and then began decreasing across the 20s (Moses-Payne et al., 2022). Thus, adolescents may attend to the valence of self-relevant social information, which may translate into enhanced LPP amplitudes during trait adjective encoding. This pattern of valence processing would therefore suggest an inverted-U pattern of development, rather than a linear progression as is typically assumed. To examine the developmental progression of attending to valence cues during behavioural endorsement and neural encoding, future work should examine the LPP response to encoding positive and negative trait adjectives in adolescence. Indeed, the LPP has been identified as a useful measure to track the development of emotion regulation abilities across development (MacNamara et al., 2022), and consequently may be useful for tracking when valence cues become attended to in the context of self-referential processing.

5.3 Implications of Individual Differences in Referent and Valence Processing for Behaviour and Development.

In Chapter 4, I examined how individual differences in processing biases are related to temperament (i.e., EC and surgency) and to real-world social behaviours. To do so, I created a novel coding scheme to characterize the content of children's conversational styles over a 5-minute interaction. I was particularly interested in seeing whether self-referential and positivity biases that are, in theory, related to core aspects of social functioning, were reflected in children's everyday communications. I showed that children *were* talking more about themselves (the "self-referential bias") than other people and did share proportionally more positive than negative information (the "positivity bias"; see proportion scores in Table 7; Section 4.2.3). However, the coding approach taken in Chapter 4 (creating composite scores based on the content of children's verbalizations rather than focusing on broader aspects of social engagement) did not produce behavioural constructs that were associated with each child's biases. Therefore, there is no evidence to suggest that individual differences in neural and behavioural responses on the standard SRET paradigm are directly related to comparable biases in the ways children present themselves in novel social contexts.

The novelty of attempting to examine how individual differences in the self-referential and positivity-biases correlate with real-world behaviours sets the stage for future work to examine other aspects of social interactions. The cognitive biases captured in the lab may be more directly associated with intermediate, or mediating, social cognitive processes. For example, ToM is of particular importance for social development, allowing one to take on the perspective of someone else, and providing the foundation for the development of prosocial skills such as empathy (Carrington & Bailey, 2009). Importantly, adaptive use and development of ToM requires cognitive flexibility and emotion regulation (i.e., EC) to engage with others appropriately (Geangu et al., 2011), and is critical in the development of self-referential processing. Support for the association between ToM and self-referential processing for social development is apparent in individuals with an Autism Spectrum Disorder (ASD). Some work has identified a reduced self-referential bias across memory indices in those with an ASD (Burrows et al., 2017; Grisdale et al., 2014; Henderson et al., 2009; although see Lind et al., 2020 for conflicting findings) as well as impaired autobiographical memories (Goddard et al., 2014; Uddin, 2011). Moreover, adults with an ASD display reduced LPP amplitudes in response to social stimuli relative to neurotypicals (i.e., faces; Benning et al., 2016; Keifer et al., 2019), which is thought to reflect impaired motivational responding to social information. Such atypical neural responses have been associated with the magnitude of childhood social impairments in ASD, with those who maintained the typical Self-Other cortical distinctions as indicated by fMRI scans experiencing less severe social impairments (Lombardo et al., 2010). Relatedly, individuals with an ASD do not develop ToM abilities at the same rate as their typically developing peers (Hughes & Leekam, 2004; Williams et al., 2010). These impairments are thought to underscore the social difficulties experienced by those with an ASD. Thus, while self-referential processing appears to be related to social behaviours, this bias may be more closely tied to specific social cognitive abilities like ToM which are in turn related to real-world social behaviours.

I found it curious that despite the robustness of the self-referential bias within the lab, I found no associations between children's encoding of trait adjectives in a self- compared to other-referential contexts with their observable conversational styles (Chapter 4). However, I believe future work should continue down this avenue of examining how individual differences in self-referential processing influence social behaviours and relationship formation (Figure 15). While non-significant, I did find a trending association between a reduced self-referential bias in children's LPP (i.e., reduced self-other LPP amplitude differences) and increased Self-Disclosure behaviours (sharing emotional and trait information; dotted line Figure 15). Previous work in healthy adults has demonstrated that a reduced self-other distinction across ERPs and memory occurs when the other character is considered proximally close to oneself (i.e., a mother, close friend; Aron et al., 1991; Symons & Johnson, 1997). However, adults with ASD have reduced self-other differences in memory, endorsement, and in cortical differentiation in fMRI studies, though as far as I know there has been no direct examination of self- compared to other-referential processing across ERPs in an ASD population. This contrast between the role of a reduced self-other difference in healthy adults and adults with an ASD may suggest that a moderating factor of personality or temperament is critical in differentiating the function of a reduced self-other bias. For example, the tendency to be affiliative describes the motivation to engage and connect with others. Perhaps the children in our sample who had a reduced LPP amplitude differences for trait adjectives encoded as self- compared to other-referential were more affiliative, and consequently, were generally more motivated to find connections with their peer during the *Get to Know You* task (Chapter 4). Future work should consider what factors modulate the magnitude of ERP amplitudes following self- compared to other-referential cues in both healthy and atypically developing individuals. Moreover, future work could directly examine how the magnitude of ERP responses to self- compared to other-referential cues changes as a function of friendship status, or as a function of time spent together with a developing friendship. Such work may identify an association between individual differences in the self-referential bias in the formation of close peer relationships and adaptive social behaviours (Figure 15).

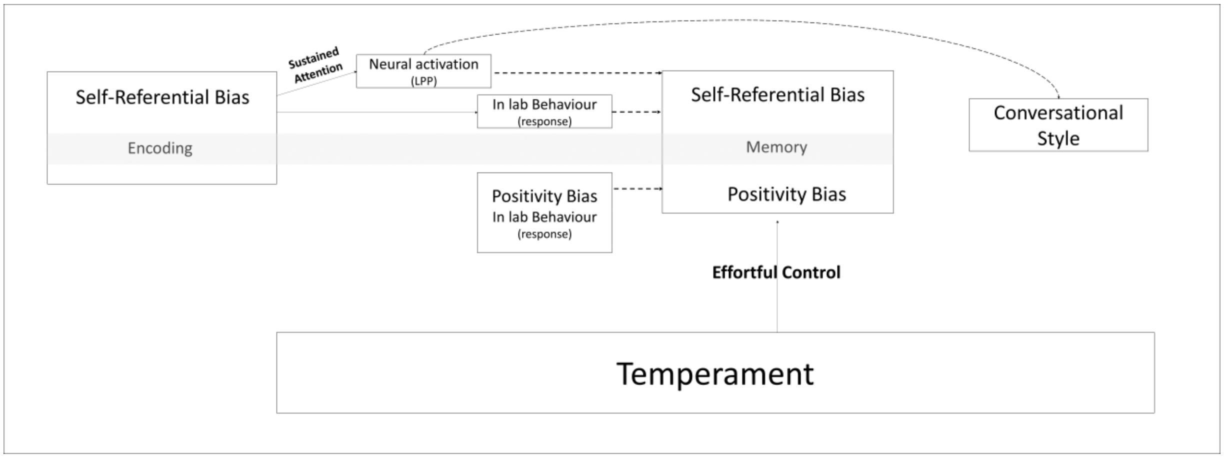


Figure 15. Individual differences in cognitive biases and temperament in guiding behaviour.

The variability in children's memory for positive relative to negative trait adjectives was associated with the relative strength of the positivity-bias associated with effortful control. While I found no support for other associations with children's cognitive biases and temperament or conversational styles, future work should continue to examine these potential associations with other aspects of personality and behaviour which I did not capture within this thesis.

Understanding individual differences in the self-referential and positivity bias across development may have implications for identifying effective intervention methods for individuals at risk for developing internalizing disorders. Previous work has demonstrated that negative-valence processing biases during encoding and memory are related to the onset and maintenance of depressive symptoms (Mogg et al., 2006; Speed et al., 2016; Watson & Clark, 1995). However, the good news is that valence-related biases are modifiable and therefore may be targetable for interventions (Alejandre-Lara et al., 2022). This recent study examined how targeting self-referential and valence-related biases in a mindfulness-based intervention program improves depressive symptoms in those with mild to severe depressive symptoms. Participants completed a self-referential task (i.e., SRET; Chapter 3), with the primary measure being recall memory for positive and negative trait adjectives, presented in either a self-referential condition (i.e., "does this word describe you?") or a physical attributes condition (i.e., was this word printed in uppercase letters?"). Participants completed this self-referential task before and after an 8-week mindfulness training program, as well as at a 20-week follow-up. A reduction of a negative self-referential bias and an increase in positive self-referential bias in memory (but not self-referential biases on its own) were associated with improvements of depressive symptoms from baseline to the 20 week follow up. In fact, improvements in recollecting positive self-referential memory was a stronger fit to the model (i.e., reducing depressive symptoms) relative to a reduction in negative self-referential memory, suggesting the importance of positive self-referential memory in particular for adaptive development.

However, this intervention study was in adults aged 18-65 years, and consequently it remains unclear whether this method of intervention would be beneficial for an adolescent population.

5.4 Conclusion.

Overall, my thesis supports the role of sustained attention following self-referential cues which improves memory; however, I did not find support for a positivity bias at encoding nor in memory indices. Consequently, the encoding of and memory for valence cues remain unclear and are likely highly dependent on specific task parameters and possibly individual differences. While valence effects were less reliably captured relative to the effects of self-referential processing, temperamental EC in children was associated with better memory for positive relative to negative information in recall. In contrast, the more robust effect of self-referential encoding was not associated with temperament. What has yet to be elucidated is what aspects of temperament further contribute to social behaviour and development, or *what* behaviours are best to measure to identify the relations between temperament and attentional biases. Identifying the functional significance of the robust self-referential bias in attention may have implications for identifying individuals at risk of developing internalizing disorders, externalizing disorders, or simply to aid individuals in making friends in novel circumstances.

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Appendices

APPENDIX A

Table A1. Summary of participant characteristics from each empirical study.

Study 1 Sample Characteristics			
Behaviour Data		**EEG Data**	
N	Age: Range; Mean (SD)	N	Age: Range; Mean (SD)
30; 19 female	18-24; 19.67 (1.50)	25; 15 female	18-24; 19.5 (1.54)
Study 2 and 3 Sample Characteristics			
Behaviour Data		**EEG Data**	
N	Age: Range; Mean (SD)	N	Age: Range; Mean (SD)
62; 42 female	9-11.92; 10.17 (.772)	49; 30 female	9-12; 10.18 (.750)

APPENDIX B

Table B1. Descriptive statistics for each word list originally used in Hudson and colleagues (2020). Length is reported in number of characters; valence, arousal, and dominance reflect the normative ratings taken from Warriner, Kuperman, and Brysbaert (2013).

		Length		**Valence**		**Arousal**		**Dominance**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
List 1									
	Positive	6.56	1.37	7.48	0.36	4.77	0.91	6.77	0.47
	Negative	6.31	1.45	2.60	0.27	4.78	0.71	3.89	0.71
List 2									
	Positive	6.47	1.37	7.49	0.36	4.93	0.96	6.70	0.41
	Negative	5.87	1.45	2.60	0.28	4.87	0.76	4.11	0.53
List 3									
	Positive	6.75	1.24	7.48	0.35	4.71	0.97	6.66	0.48
	Negative	6.17	1.42	2.60	0.27	4.87	0.76	3.97	0.65

Table B2. List of all possible sentences used through the task (Chapter 2). List 1 and list 2 were presented in the first two blocks, with list 3 providing distractor adjectives in the recognition task. All three lists were then presented in the subsequent 3 additional experimental blocks to increase the trial count. The referent of each statements (bolded below) was counterbalanced across the 5 blocks.

List 1	**List 2**	**List 3**
He/She thinks **she/he/you** is/are **relaxing**	He/She thinks **she/he/you** is/are **cheerful**	He/She thinks **she/he/you** is/are **faithful**
He/She thinks **she/he/you** is/are **exciting**	He/She thinks **she/he/you** is/are **talented**	He/She thinks **she/he/you** is/are **humorous**
He/She thinks **she/he/you** is/are **fabulous**	He/She thinks **she/he/you** is/are **friendly**	He/She thinks **she/he/you** is/are **thankful**
He/She thinks **she/he/you** is/are **pleasing**	He/She thinks **she/he/you** is/are **blissful**	He/She thinks **she/he/you** is/are **positive**
He/She thinks **she/he/you** is/are **original**	He/She thinks **she/he/you** is/are **spirited**	He/She thinks **she/he/you** is/are **generous**
He/She thinks **she/he/you** is/are **grateful**	He/She thinks **she/he/you** is/are **truthful**	He/She thinks **she/he/you** is/are **wonderful**
He/She thinks **she/he/you** is/are **carefree**	He/She thinks **she/he/you** is/are **adorable**	He/She thinks **she/he/you** is/are an **optimist**
He/She thinks **she/he/you** is/are **reliable**	He/She thinks **she/he/you** is/are **pleasant**	He/She thinks **she/he/you** is/are **valuable**
He/She thinks **she/he/you** is/are **terrific**	He/She thinks **she/he/you** is/are **selfless**	He/She thinks **she/he/you** is/are **flawless**
He/She thinks **she/he/you** is/are **creative**	He/She thinks **she/he/you** is/are **charming**	He/She thinks **she/he/you** is/are **annoying**
He/She thinks **she/he/you** is/are **artistic**	He/She thinks **she/he/you** is/are **shameful**	He/She thinks **she/he/you** is/are **desolate**
He/She thinks **she/he/you** is/are **nuisance**	He/She thinks **she/he/you** is/are **cowardly**	He/She thinks **she/he/you** is/are **defeated**
He/She thinks **she/he/you** is/are **wasteful**	He/She thinks **she/he/you** is/are **dreadful**	He/She thinks **she/he/you** is/are **rejected**
He/She thinks **she/he/you** is/are **wretched**	He/She thinks **she/he/you** is/are a **disgrace**	He/She thinks **she/he/you** is/are **hopeless**
He/She thinks **she/he/you** is/are **negative**	He/She thinks **she/he/you** is/are **horrible**	He/She thinks **she/he/you** is/are **terrible**
He/She thinks **she/he/you** is/are **helpless**	He/She thinks **she/he/you** is/are **lovable**	He/She thinks **she/he/you** is/are **healthy**
He/She thinks **she/he/you** is/are **excited**	He/She thinks **she/he/you** is/are **pleased**	He/She thinks **she/he/you** is/are **playful**
He/She thinks **she/he/you** is/are **awesome**	He/She thinks **she/he/you** is/are **amusing**	He/She thinks **she/he/you** is/are **special**
He/She thinks **she/he/you** is/are **amazing**	He/She thinks **she/he/you** is/are a **dreamer**	He/She thinks **she/he/you** is/are **helpful**
He/She thinks **she/he/you** is/are **hopeful**	He/She thinks **she/he/you** is/are **vibrant**	He/She thinks **she/he/you** is/are a **thinker**
He/She thinks **she/he/you** is/are **adoring**	He/She thinks **she/he/you** is/are **radiant**	He/She thinks **she/he/you** is/are **relaxed**
He/She thinks **she/he/you** is/are **welcome**	He/She thinks **she/he/you** is/are **admired**	He/She thinks **she/he/you** is/are **skilled**
He/She thinks **she/he/you** is/are **perfect**	He/She thinks **she/he/you** is/are **capable**	He/She thinks **she/he/you** is/are a **crybaby**
He/She thinks **she/he/you** is/are **genuine**	He/She thinks **she/he/you** is/are **awkward**	He/She thinks **she/he/you** is/are a **cheater**
He/She thinks **she/he/you** is/are a **quitter**	He/She thinks **she/he/you** is/are **callous**	He/She thinks **she/he/you** is/are a **mistake**

He/She thinks **she/he/you** is/are **pitiful**	He/She thinks **she/he/you** is/are an **outcast**	He/She thinks **she/he/you** is/are **unlucky**
He/She thinks **she/he/you** is/are **trouble**	He/She thinks **she/he/you** is/are **useless**	He/She thinks **she/he/you** is/are **fearful**
He/She thinks **she/he/you** is/are **annoyed**	He/She thinks **she/he/you** is/are a **lowlife**	He/She thinks **she/he/you** is/are **ashamed**
He/She thinks **she/he/you** is/are **vicious**	He/She thinks **she/he/you** is/are **furious**	He/She thinks **she/he/you** is/are **hostile**
He/She thinks **she/he/you** is/are **painful**	He/She thinks **she/he/you** is/are **harmful**	He/She thinks **she/he/you** is/are **violent**
He/She thinks **she/he/you** is/are **jealous**	He/She thinks **she/he/you** is/are **hateful**	He/She thinks **she/he/you** is/are **joyful**
He/She thinks **she/he/you** is/are **unhappy**	He/She thinks **she/he/you** is/are a **winner**	He/She thinks **she/he/you** is/are **dreamy**
He/She thinks **she/he/you** is/are **honest**	He/She thinks **she/he/you** is/are **lovely**	He/She thinks **she/he/you** is/are **heroic**
He/She thinks **she/he/you** is/are **genius**	He/She thinks **she/he/you** is/are **joyous**	He/She thinks **she/he/you** is/are **cheery**
He/She thinks **she/he/you** is/are **gentle**	He/She thinks **she/he/you** is/are **unique**	He/She thinks **she/he/you** is/are **lively**
He/She thinks **she/he/you** is/are **clever**	He/She thinks **she/he/you** is/are **useful**	He/She thinks **she/he/you** is/are **secure**
He/She thinks **she/he/you** is/are **upbeat**	He/She thinks **she/he/you** is/are **superb**	He/She thinks **she/he/you** is/are **uneasy**
He/She thinks **she/he/you** is/are **cranky**	He/She thinks **she/he/you** is/are **stupid**	He/She thinks **she/he/you** is/are **broken**
He/She thinks **she/he/you** is/are **snotty**	He/She thinks **she/he/you** is/are **grumpy**	He/She thinks **she/he/you** is/are **horrid**
He/She thinks **she/he/you** is/are **scared**	He/She thinks **she/he/you** is/are **smelly**	He/She thinks **she/he/you** is/are **creepy**
He/She thinks **she/he/you** is/are **lonely**	He/She thinks **she/he/you** is/are **unkind**	He/She thinks **she/he/you** is/are **afraid**
He/She thinks **she/he/you** is/are **wicked**	He/She thinks **she/he/you** is/are a **failure**	He/She thinks **she/he/you** is/are **greedy**
He/She thinks **she/he/you** is/are a **coward**	He/She thinks **she/he/you** is/are a **victim**	He/She thinks **she/he/you** is/are **sunny**
He/She thinks **she/he/you** is/are **happy**	He/She thinks **she/he/you** is/are **smart**	He/She thinks **she/he/you** is/are **great**
He/She thinks **she/he/you** is/are **sweet**	He/She thinks **she/he/you** is/are **loved**	He/She thinks **she/he/you** is/are **fancy**
He/She thinks **she/he/you** is/are **funny**	He/She thinks **she/he/you** is/are **jolly**	He/She thinks **she/he/you** is/are **witty**
He/She thinks **she/he/you** is/are **brave**	He/She thinks **she/he/you** is/are **loyal**	He/She thinks **she/he/you** is/are a **giver**
He/She thinks **she/he/you** is/are **lucky**	He/She thinks **she/he/you** is/are **clean**	He/She thinks **she/he/you** is/are **super**
He/She thinks **she/he/you** is/are **noble**	He/She thinks **she/he/you** is/are **proud**	He/She thinks **she/he/you** is/are **scary**
He/She thinks **she/he/you** is/are **messy**	He/She thinks **she/he/you** is/are **bored**	He/She thinks **she/he/you** is/are **bossy**
He/She thinks **she/he/you** is/are **nasty**	He/She thinks **she/he/you** is/are **unfit**	He/She thinks **she/he/you** is/are **wimpy**
He/She thinks **she/he/you** is/are a **crook**	He/She thinks **she/he/you** is/are a **loser**	He/She thinks **she/he/you** is/are **boring**
He/She thinks **she/he/you** is/are a **faker**	He/She thinks **she/he/you** is/are **cruel**	He/She thinks **she/he/you** is/are **bully**
He/She thinks **she/he/you** is/are **tense**	He/She thinks **she/he/you** is/are **angry**	He/She thinks **she/he/you** is/are **phony**

He/She thinks **she/he/you** is/are **fussy**	He/She thinks **she/he/you** is/are **upset**	He/She thinks **she/he/you** is/are **good**
He/She thinks **she/he/you** is/are **awful**	He/She thinks **she/he/you** is/are **glad**	He/She thinks **she/he/you** is/are **fair**
He/She thinks **she/he/you** is/are **kind**	He/She thinks **she/he/you** is/are **wise**	He/She thinks **she/he/you** is/are **glum**
He/She thinks **she/he/you** is/are **epic**	He/She thinks **she/he/you** is/are **weak**	He/She thinks **she/he/you** is/are a **snob**
He/She thinks **she/he/you** is/are a **pest**	He/She thinks **she/he/you** is/are **fake**	He/She thinks **she/he/you** is/are a **slob**
He/She thinks **she/he/you** is/are a **brat**	He/She thinks **she/he/you** is/are **ugly**	He/She thinks **she/he/you** is/are **hurt**
He/She thinks **she/he/you** is/are **lost**	He/She thinks **she/he/you** is/are **dumb**	He/She thinks **she/he/you** is/are a **jerk**
He/She thinks **she/he/you** is/are **mean**	He/She thinks **she/he/you** is/are **evil**	He/She thinks **she/he/you** is/are **fun**
He/She thinks **she/he/you** is/are a **liar**	He/She thinks **she/he/you** is/are **sick**	He/She thinks **she/he/you** is/are **sad**
He/She thinks **she/he/you** is/are **rude**	He/She thinks **she/he/you** is/are **fat**	He/She thinks **she/he/you** is/are **peaceful**

APPENDIX C

Classic analysis of Event-Related potential data (Chapter 2).

ERP processing and analysis.

To follow up on McCrackin and Itier (2018), mean amplitudes were calculated across left (P9, TP9, PO9) and right (P10, TP10, PO10) posterior electrodes, and left (C1, C3, CP1, and FC1), midline (CPz, Cz, Fz, and FCz) and right (C2, C4, CP2, and FC2) frontocentral and centroparietal clusters between 200-400ms (EPN)[14], 400-600ms (eLPP), 600-800ms and 800-1000ms (lLPP). See table B1 for descriptives of each ERP waveform averaged across posterior clusters and frontocentral and centroparietal clusters.

Across posterior sites, the EPN, eLPP and lLPP were subjected to a series of 2 (referent: self, other) x 2 (valence; positive negative) x 2 hemisphere (left; right) repeated measures ANOVAs in SPSS Statistics 22. The lLPP included the additional factor of time (2 levels: 600-800ms; 800-1000ms). At frontocentral sites, the hemisphere factor was replaced with a cluster factor (3 levels: left; midline; right). All follow-up tests were conducted with a Bonferroni corrected significance threshold. Greenhouse-Geisser corrected degrees of freedom were reported when Mauchly's Test of sphericity was significant.

Results.

Mean Amplitude analyses over Posterior electrodes (Figure B1).

EPN (200-400ms). The main effect of hemisphere was significant, $F(1, 24) = 7.19$, MSE = 11.10, $p = .013$, $\eta_p^2 = .230$, such that amplitudes on the right were more positive relative to the left. However, there were no interactions between any factor and hemisphere (all p's > .742). The main effect of referent, $F(1, 24) = 1.50$, MSE = .574, $p = .232$, $\eta_p^2 = .059$, valence, $F(1, 24) = .604$, MSE = .787, $p = .445$, $\eta_p^2 = .025$, and their interaction, $F(1, 24) = .046$, MSE = .889, $p = .831$, $\eta_p^2 = .002$, were not significant.

eLPP timing at posterior sites (400-600ms). The main effect of hemisphere, $F(1, 24) = 2.06$, MSE = 10.49, $p = .165$, $\eta_p^2 = .079$, and interactions with hemisphere were not significant (all p's > .373). The main effect of referent was significant, $F(1, 24) = 9.66$, MSE = .665, $p = .005$, $\eta_p^2 = .287$, with amplitudes for faces following other-relevant trials being more positive relative to faces presented following self-

[14] Although the EPN is typically analyzed at posterior sites and the LPP at anterior sites, this study analyzed each component at both sites based on the idea that some of the EPN activity can be seen polarity reversed at opposite sites due to the use of the average reference (Dien, 1998).

relevant trials. The main effect of valence, *F(*1, 24) = .355, MSE = 1.27, p = .557, η_p^2 = .015, and the referent by valence interaction, *F(*1, 24) = 2.617, MSE = .667, p = .119, η_p^2 = .098 were not significant.

lLPP timing at posterior sites (600-1000ms). The main effect of time was significant, *F(*1, 24) = 68.32, MSE = 7.96, $p < .001$, η_p^2 = .740 with amplitudes in the second time window (800-1000ms) being more negative relative to the first (600-800ms) time window. The main effect of hemisphere was significant, *F(*1, 24) = 7.10, MSE = 14.58, p = .014, η_p^2 = .228, with amplitudes in the right hemisphere being more negative relative to the left hemisphere. However, no interactions between hemisphere or time were significant (all *p*'s > .252). The main effect of referent was significant, *F(*1, 24) = 5.55, MSE = 1.80, p = .027, η_p^2 = .188, with amplitudes for faces following other-relevant trials being more positive relative to faces following self-relevant trials. The main effect of valence, *F(*1, 24) = .814, MSE = 3.06, p = .376, η_p^2 = .033, and the referent by valence interaction, *F(*1, 24) = 2.80, MSE = 2.22, p = .108, η_p^2 = .104, were not significant.

Mean Amplitude analyses over Frontocentral and Centroparietal Clusters (Figure B2).

EPN timing at anterior sites (200-400ms). The main effect of cluster was significant, *F(*1.340, 32.157) = 8.13, MSE = 4.43, p = .004, , η_p^2 = .253, as was the cluster by referent interaction, *F(*2, 48) = 4.44, MSE = .057, p = .017, η_p^2 = .156. However, no follow up tests were significant. The main effects of referent, *F(*1, 24) = 1.65, MSE = .716, p = .211, η_p^2 = .034, valence, *F(*1, 24) = .044, MSE = .434, p = .835, η_p^2 = .002, and their interaction, *F(*1, 24) = .845, MSE = .761, p = .367, η_p^2 = .034 were not significant.

eLPP (400-600ms). The main effect of cluster was significant, *F(*1.484, 35.609) = 7.209, p = .005, MSE = 3.48, η_p^2 = .231, as was the cluster by referent interaction, *F(*2, 48) = 3.28, MSE = .110, p = .046, η_p^2 = .120. Follow-up ANOVAs indicated this was driven by a marginal main effect of referent in the midline cluster, *F(*1, 24) = 6.38, MSE = .347, p = .019, η_p^2 = .210, such that amplitudes for faces following self-relevant trials were more positive than faces following other-relevant trials. The main effect of referent, *F(*1, 24) = 3.21, MSE = .631, p = .086, η_p^2 = .118, valence, *F(*1, 24) = .078, MSE = .850, p = .783, η_p^2 = .003, and their interaction, *F(*1, 24) = .221, MSE = 1.07, p = .642, η_p^2 = .009 were not significant.

lLPP (600-1000ms). The main effect of time was significant, *F(*1, 24) = 63.49, MSE = 4.15, $p < .001$, η_p^2 = .726 such that amplitudes in the second time window (800-1000ms) were more positive relative to the first (600-800ms) time window. The main effect of cluster was not significant, *F(*2, 48) = .052, MSE = 4.49, p = .949, η_p^2 = .002. Neither were the main effects of referent, *F(*1, 24) = 1.11, MSE = 2.04, p = .303, η_p^2 = .044, valence, *F(*1, 24) = .989, MSE = 2.11, p = .330, η_p^2 = .040, nor their interaction, *F(*1, 24) = .585, MSE = 2.91, p = .452, η_p^2 = .024.

The valence by cluster by time three-way interaction was significant, $F(2, 48) = 4.73$, MSE = .024, p = .013, $\eta_p^2 = .135$. Follow up ANOVAs across each time window indicate this was driven by the 600-800ms epoch only, where the main effect of valence was significant, $F(1, 24) = 10.50$, MSE = .888, p = .003, $\eta_p^2 = .304$, such that amplitudes for faces following negative trials were enhanced relative to faces following positive trials. The referent by valence interaction was not significant, $F(1, 24) = 1.71$, MSE = 1.40, $p = .203$, $\eta_p^2 = .067$. All factors of interest significantly interacted with cluster, however, no follow up ANOVAs across each cluster was significant.

Table C1. Means amplitudes (in µV) with standard deviations, across each cluster for each of the four conditions (Self-Positive; Self-Negative; Other-Positive; Other-Negative). The EPN, eLPP, and lLPP amplitudes are also averaged across the left and right posterior clusters, and the left, middle, and right Frontocentral and Centroparietal clusters.

		Self-Positive		**Self-Negative**		**Other-Positive**		**Other-Negative**	
ERP	**Time(ms)**	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Posterior clusters									
EPN	200-400ms	3.18	(2.93)	3.31	(3.04)	3.54	(3.11)	3.22	(2.92)
eLPP	400-600ms	1.10	(2.67)	1.20	(2.71)	1.65	(2.35)	1.37	(2.43)
	600-800ms	-1.95	(3.10)	-1.95	(3.00)	-1.47	(2.97)	-1.84	(3.08)
lLPP	800-1000ms	-4.40	(3.25)	-4.21	(3.26)	-3.74	(3.13)	-4.18	(3.29)
Frontocentral and Centroparietal clusters									
EPN	200-400ms	-2.81	(1.85)	-2.89	(1.92)	-3.03	(1.79)	-2.92	(1.73)
eLPP	400-600ms	-1.13	(1.50)	-1.15	(1.56)	-1.35	(1.33)	-1.26	(1.41)
	600-800ms	0.65	(1.53)	0.69	(1.56)	0.54	(1.43)	0.71	(1.47)
lLPP	800-1000ms	2.08	(1.55)	2.06	(1.47)	1.73	(1.16)	2.01	(1.28)

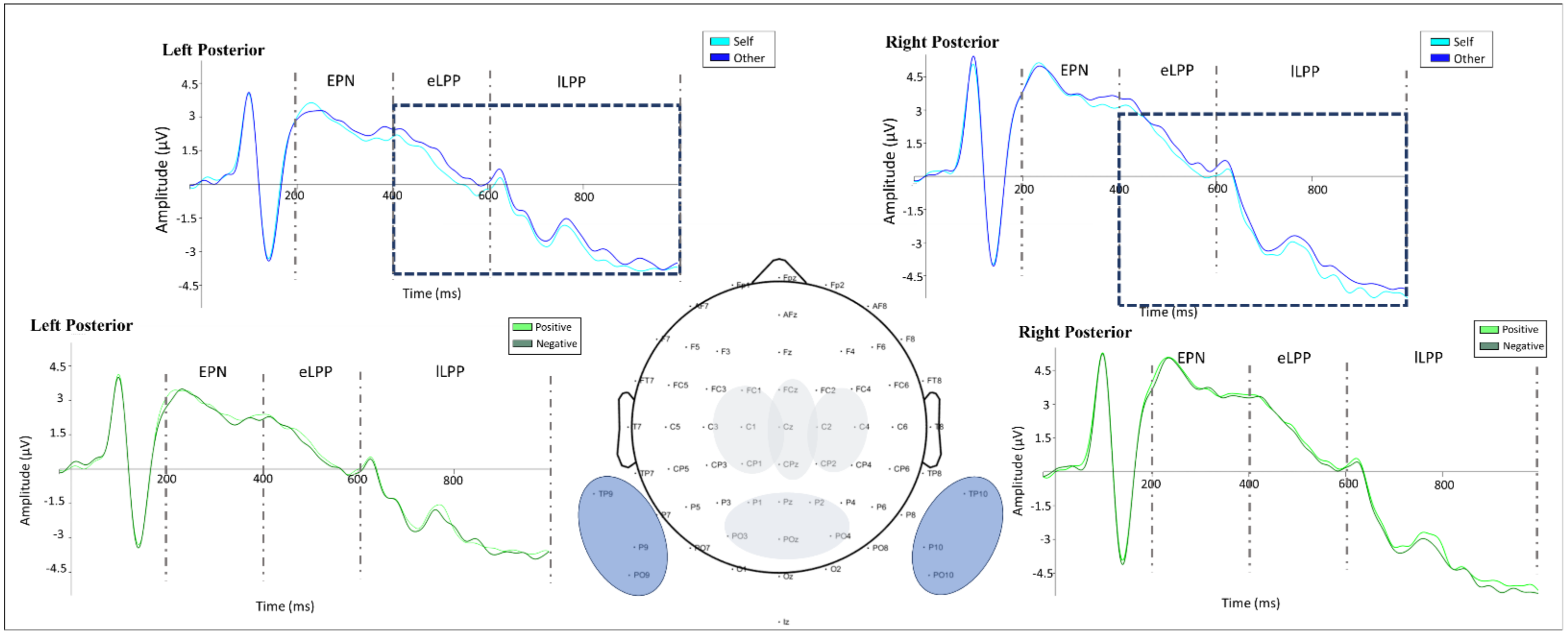

Figure C1. Effects of self-relevance (top panels) and valence (bottom panels) at posterior clusters; significant sections are outlined with dotted rectangles.

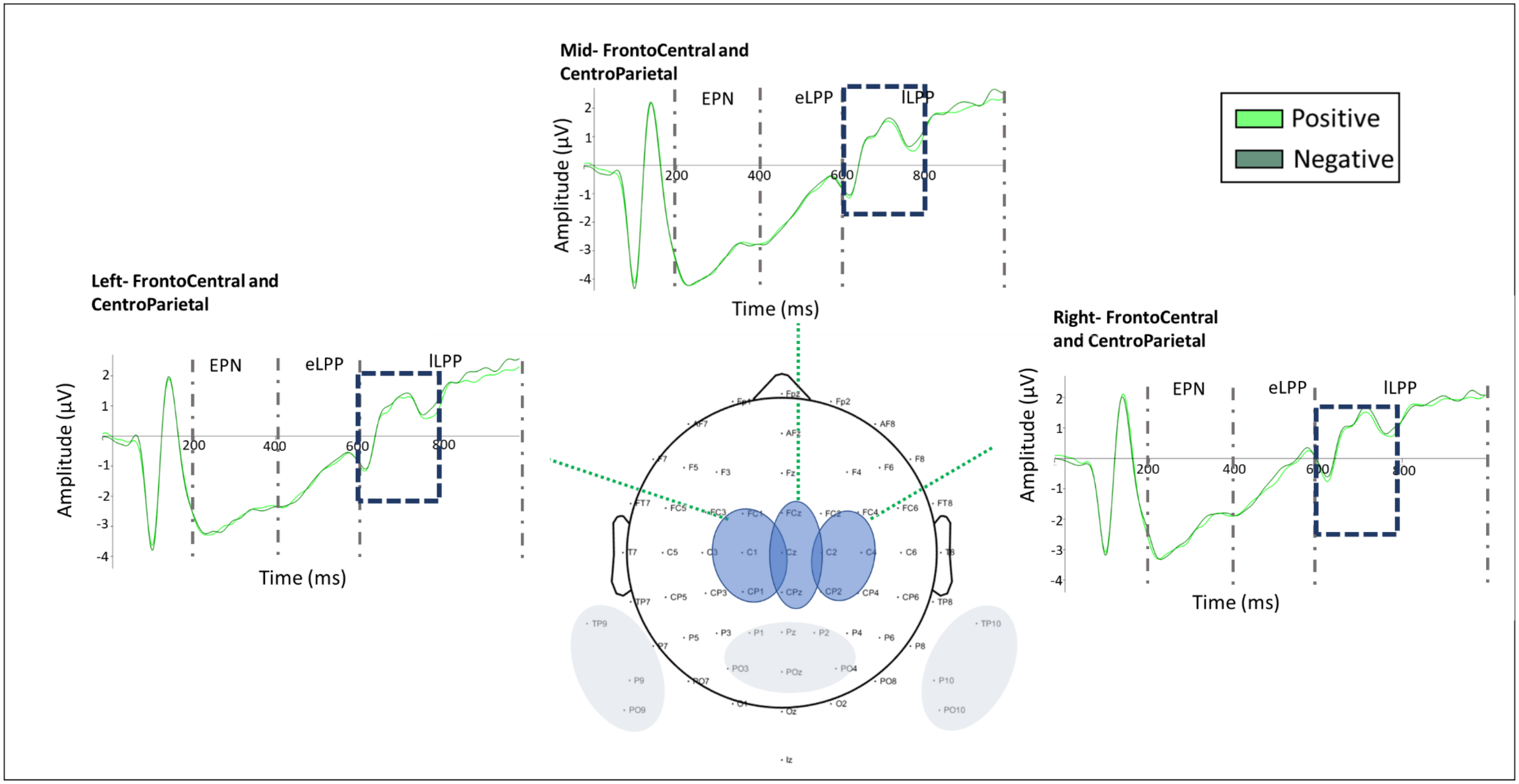

Figure C2. Valence effects across Frontocentral and Centroparietal clusters. Significant effects outlined between 600-800ms with dotted rectangles.

APPENDIX D

Coding Scheme.

Classifying Seeks and Shares: During a separate and unrelated round of coding, coders reviewed each GTKY session and marked instances of each child's *Seeks, Shares*, and *Responses* with their unfamiliar peer. *Seeks* were defined as any instances in which a child asked a question to their peer whereas *Shares* were defined as instances in which a child told their peer something about themselves such as a thought, feeling or opinion. Based on 16 cases, the reliability of *Seeks* was α=.997, and Shares was α=.876. I used these initial *Seek/Share* codes as the basis of my coding scheme, which further classified each child's seeks and shares in terms of the (a) referent (Self, Other), (b) content (Personal, Declarative; Trait, Fact), (c) valence (Positive, Negative, Neutral), and (d) function (Closed, Open).

At coding Level 1, each previously identified *Seek* and *Share* was classified as either a new conversational topic (coded as *Change Topic*) or a continuation of the current conversation (coded as *Continue Topic*). The very first statement in any GTKY session was coded as a *Change* topic by default.

At coding Level 2, each previously identified *Seek* and *Share* was further classified as *Self* if the child was talking about themselves or a close family member or friend, or *Other* if they asked a question or made a comment about the other participant.

At coding Level 3, each *Self* and *Other* statement were characterized as either *Personal* or *Declarative*. A *Personal Self* described any personal statement, whereas a *Declarative Self* described any statement that provided a non-personal piece of information (e.g., talking about the weather, the size of a school, the design of the testing room, etc.). A *Personal Other* referred to any question issued regarding the other child's life, while a *Declarative Other* was any non-personal question (e.g., "Was it snowing when you got here?"). Following any *Other* codes (Level 2), or *Declarative* code (Level 3), coders skipped ahead to Level 6.

At coding Level 4, all *Personal Self* codes were further classified as a *Trait* (a thought, feeling, preference, or a physical trait) or a *Fact* (an anecdote describing a personal experience, or describing something about someone close to them such as a family member or friend).

At coding Level 5, each *Trait* and *Fact* was further coded for its valence. If the participant explicitly said a positive or negative trait adjective or opinion (e.g., "I like/hate..."; "It was awesome/horrible…") it would receive a subsequent *Positive* or *Negative* code. If no explicit positive or negative word was said, or if both were mentioned at the same time (ex., "My brother is *annoying*, but I *love* him."), it was coded as *Neutral*. This design decision occurred as having both ‘cancelled out’ the direction of the valence of the statement.

At coding Level 6, all codes (*Personal Self/Other; Declarative Self/Other*) were coded as *Open* or *Closed*, depending on whether they allowed the conversation to continue (*Open*), or if they provided a shallow or random statement which ended the conversation (*Closed*).

APPENDIX E

Exploratory Correlations.

Table E1**.** Summary of correlations between participants age and sex with the *Get To Know You*, SRET, and temperament variables of interest from Chapter 4. Female participants were coded as the referent.

Correlation Summary							
Variable	Social Engagement	Self-Disclosure	PN Recall	PN *d'*	SO ERP	Surgency	EC
1. Age	-.308*	-.118	.128	.096	-.094	-.090	-.093
2. Sex (female)	.077	-.219	-.205	-.519**	-.249	.214	-.049

*Significant at <.05
**Significant at <.01

Exploratory mediation analyses.

Mediation analyses using model 4 in the PROCESS macro in SPSS were conducted to examine any indirect effects of temperament on social competence through information processing biases.

Table E2**.** Summary for each mediation model. Lower limits (LL) and upper limits (UL) of each 95% Confidence Interval (CI) are reported, with indirect effects reported under a bootstrap of 5000.

Outcome Variable/ Predictor	**Independent Variables**	**B**	**(SE)**	***t***	***p***	**95% CI**	
						LL	**UL**
Self-Disclosure							
Surgency							
	Surgency	.025	(.071)	.359	.722	[-.111, .994]	
	PN Recall	-.018	(.015)	-1.18	.245	[-.049, .013]	
	PN *d'*	.158	(.106}	1.49	.144	[-.056, .372]	
	SO ERP	-.025	(.020)	-1.21	.232	[-.065, .016]	
	Bootstrapping indirect effect of Surgency on Self Disclosure						
	Indirect path	**Estimated Effect**	**95% CI LL, UL**				
	PN Recall	-.008	[-.075, .047]				
	PN *d'*	-.011	[-.049, .029]				
	SO ERP	-.0004	[-.035, .032]				
Social Engagement							
Surgency							
	Surgency	-.017	(.051)	-.341	.735	[-.121, .086]	
	PN Recall	.006	(.011)	.560	.579	[-.016, .029]	
	PN *d'*	.004	(.077)	.053	.958	[-.151, .159]	
	SO ERP	.002	(.015)	.162	.872	[-.027, .032]	
	Bootstrapping indirect effect of Surgency on Social Engagement						
	Indirect path	**Estimated Effect**	**95% CI LL, UL**				
	PN Recall	.003	[-.034, .035]				
	PN *d'*	.0003	[-.016, .021]				
	SO ERP	<.001	[-.028, .018]				
Self-Disclosure							
Effortful Control							
	EC	.002	(.103)	.019	.985	[-.206, 210]	
	PN Recall	-.009	(.017)	-.538	.594	[-.042, .024]	
	PN *d'*	.133	(.111)	1.20	.238	[-.091, .356]	
	SO ERP	-.034	(.020)	-1.733	.090	[-.074, .006]	
	Bootstrapping indirect effect of Effortful Control of Self Disclosure						
	Indirect path	**Estimated Effect**	**95% CI LL, UL**				
	PN Recall	-.023	[-.205, .060]				
	PN *d'*	.026	[-.012, .115]				
	SO ERP	.024	[-.012, .093]				
Social Engagement							
Effortful Control							
	EC	.012	(.070)	.164	.871	[-.130, .153]	
	PN Recall	.008	(.011)	.724	.473	[-.015, .031]	
	PN *d'*	-.001	(.075)	-.014	.989	[-.153, .151]	
	SO ERP	-.001	(.013)	-.067	.947	[-.028, .026]	
	Bootstrapping indirect effect of Effortful Control on Social Engagement						
	Indirect path	**Estimated Effect**	**95% CI LL, UL**				
	PN Recall	.021	[-.033, .085]				
	PN *d'*	<-.001	[-.032, .037]				
	SO ERP	<.001	[-.038, .030]				