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The Social Context of Nonverbal Behaviour

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Abstract

Although nonverbal behaviour has long been a topic of research, it is often studied in isolation from social partners and the social environment. This work presents three empirical chapters that reintroduce the social environment to the investigation of nonverbal cue exchange, focusing on the value of social rewards and the perceptive and affiliative functions of nonverbal communication. Findings reported in Chapter 2 indicate that the subjective value of social rewards changes as a function of social media use saliency. Specifically, thinking about a recent social media post, but not a synchronous conversation, increases the value of social rewards, such that people are willing to forego monetary gain to see a genuine smile. In Chapter 3, I show that although the amount of nonverbal behaviour does not necessarily enhance interpersonal judgement accuracy, accuracy does increase with familiarity, suggesting that people retain and update models of specific social partners. In Chapter 4, I demonstrate that social interactions on video-chat platforms, compared to face-to-face settings, are characterized by reduced interpersonal coordination and increased self-coordination, both of which have negative downstream effects for interaction outcomes (i.e., lower liking and worse interaction quality). Together, these findings indicate that the functions of nonverbal social cues and the subsequent judgments receivers make are strongly affected by the presence of social partners and the interaction environment. Thus, because nonverbal communication contingencies change as a function of individuals, situations, and interaction modalities, investigations of nonverbal cues should prioritize diverse social contexts to foster a well-rounded understanding of nonverbal behaviour.

Keywords

Nonverbal behaviour; social cue exchange; naturalistic interactions; dyadic data analysis; social relations model; actor-partner interdependence model

Summary for Lay Audience

Conversations are the building blocks of social life. The complexity of these encounters is often overlooked, partly because the patterns of conversation are so entrenched in our development that they feel automatic and effortless. Social learning begins in the first few months of life, and patterns of nonverbal behaviour are continually reinforced through ongoing social exposure. Specifically, people learn to decipher and predict their social partners' behaviour and to coordinate their own behaviour with a partner's, all of which are important for promoting positive social outcomes and relationships.

However, social interactions are difficult to study because they are multifaceted, with behavioural influences from everyone involved. To minimize their complexity, researchers have studied social cues in isolation from the social context by simulating social partners with photographs, videos, and other means. These methods can enhance understanding of associations between behaviours and outcomes because there is careful control over the environment. However, this changes the social context substantially, meaning that these findings may fail to generalize to more natural conversations. Specifically, these effects should be replicated in natural social encounters because social behaviours are learned and reinforced through inherently social processes.

The research presented here investigates unmanipulated social encounters. My findings show that thinking about social media use, but not a recent conversation, increases the value and desire to see positive social cues, such as smiling faces. This indicates that social media may not fulfill social needs in the same way as face-to-face conversations. I also show that in a competitive game, people do not use general nonverbal signals to make accurate deductions about other people. Instead, increased familiarity with specific people and their unique behaviour is important for making accurate judgements, particularly in a competitive context. Finally, I show that conversations that occur on Zoom show less coordination between the nonverbal behaviours of interaction partners, and instead show more coordination with one's own behaviour, leading to worse quality conversation and less liking between interaction partners. Together these findings demonstrate that the social context changes the way we value, signal, and coordinate social behaviour and thus is an important consideration for researchers.

Co-Authorship Statement

Dr. Erin A. Heerey is a co-author of *The Impact of Social Media on the Subjective Value of Social Cues* (reported in Chapter 2; published in the journal of *Social Psychology and Personality Science*, https://doi.org/10.1177/19485506221130176). I conceptualized the project, collected and analyzed the data, and wrote the first drafts of the manuscript. Dr. Heerey funded the projects from an internal grant, assisted in coding the task interface, and provided guidance on the project. She also provided revisions and comments on the manuscript.

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Chapter 1

1 The Functions of Nonverbal Cues in Social Interactions

Social interactions are complex and contain a vast amount of social information, including verbal content, paralinguistic cues, gestures, postures, eye gaze, and facial expressions (e.g., Ambadar et al., 2009; Ambady & Weisbuch, 2010; Archer & Akert, 1977; Caucci & Kreuz, 2012; Sinkeviciute & Rodriguez, 2021). Yet, people seamlessly engage with one another, predicting and responding to their social partners' behaviour in what appears to be an effortless and automatic way (Bargh & Chartrand, 1999; Dijksterhuis & Bargh, 2001; Tamir & Thornton, 2018; Thornton et al., 2019a). Understanding these processes has inspired a long-standing research tradition with a large body of empirical work, spanning well over a century (e.g., Darwin, 1872; Duchenne, 1862; Dunbar et al., 2022; Ekman, 1984; Hale et al., 2020; Hess & Blairy, 2001; Hess & Bourgeois, 2010; Miles et al., 2009; Valdesolo & DeSteno, 2011). These inquiries have been widespread and interdisciplinary, with interest across many fields, including anthropology (Schmidt & Cohn, 2001), biology (e.g., Pahar et al., 2016), political science (e.g., Boussalis & Coan, 2020), neuroscience (e.g., Schultz & Frith, 2022), and psychology (e.g., Bargh & Chartrand, 1999; Heerey & Crossley, 2013; Hess & Bourgeois, 2010).

While diverse, most of this work highlights the idea that successful social interactions are critical for positive relationship and life outcomes, such as increased liking and trust of social partners (Clerke & Heerey, 2021; Salazar Kämpf et al., 2017), and overall increased social connection (Cheung et al., 2015), physical health (Fiorillo & Sabatini, 2011), and wellbeing (Sun et al., 2022). Thus, investigating the building blocks of successful interactions has been a focal point of recent psychological research. Pertinently, the work on nonverbal behaviour has been particularly enlightening, generating several theories about how people understand, process, and respond to cues from this information pathway to support successful social interactions and relationships. To facilitate a clear understanding of the research presented in this dissertation, an overview of the relevant theoretical frameworks in nonverbal behavioural research is summarized below.

1.1 Theoretical Overview

1.1.1 Basic Emotions Theory

A fair amount of the research investigating nonverbal cues has focused on facial expressions and their communicative purpose and value (e.g., Ekman & Friesen, 1982; Feldman Barrett et al., 2019; Fridlund, 1991; Heerey & Crossley, 2013; Hess & Blairy, 2001; Keltner & Buswell, 1997; Levenson, 1999; Maxwell & Davidson, 2010). Traditionally, their primary purpose has been thought to be the display of one's felt emotions (e.g., Ekman & Oster, 1979; Matsumoto et al., 2008; Pope & Smith, 1991). This idea stems, in part, from Duchenne's description of the genuine, or "Duchenne" smile, which suggested that there was a fundamental difference in the muscle activation of felt (i.e., genuine) versus faked smiles (Duchenne, 1862/1990). This work informed Darwin's theories of nonverbal behaviour, generally, and emotional expression specifically (Darwin, 1872). Pertinently, the ideas that basic and universal emotions exist and have clear physiological signatures, specific expressive displays in the face and body, are present in different animal species, and are identifiable across human cultures, are Darwinian in nature (Darwin, 1872; Ekman, 2009; George, 1994). In particular, Darwin's theory of universal emotional expressions has had a formative and ongoing influence on the contemporary fields of emotion science, nonverbal behaviour, and communication (Hess & Thibault, 2009).

More recently, Ekman and colleagues' seminal work on Basic Emotions Theory (BET) identified six basic emotions: *joy, sadness, anger, disgust, fear,* and *surprise* (Ekman, 1972; Ekman, 1990; Ekman & Friesen, 1976a; Ekman & Friesen, 1976b), with *contempt* later added as the seventh basic emotion (Ekman & Friesen, 1986; see Gu et al., 2019 for a discussion of other theories of basic emotions). In line with Darwin's original hypothesis, research has shown that people are skilled at interpreting these emotions from facial expressions, even successfully doing so across culture and language barriers (Ekman et al., 1969; Ekman et al., 1987; Ekman & Friesen, 1971; Elfenbein & Ambady, 2002)[1]. Furthermore, as Duchenne and Darwin alluded to in the late 1800s, these expressions have been linked to, and can be identified by, the unique activation patterns of specific facial muscles, known individually as "action units" (Darwin, 1872; Duchenne, 1862/1990; Ekman et al., 2002).

To measure the action units that comprise emotional expressions Ekman, Friesen, and colleagues (1976a; 1978; 2002), developed The Facial Action Coding System (FACS). Using FACS, researchers can identify individual muscle activities, that combine to produce emotional expressions. For example, the Duchenne smile is comprised of action units AU12 (the lip corner puller or zygomaticus major) and AU6 (the cheek raiser or outer orbicularis oculi)(Ekman & Friesen, 1982). This innovation paved the way for highly controlled and experimental studies of human emotional expression (e.g., Davidson, 1992; Dimberg, 1982; Dimberg & Thunberg, 2008; Ekman & Friesen, 1986). However, FACS also identifies any other combination of possible facial muscle movements, many of which are not necessarily tied to emotional experiences (Hassin et al., 2013; Feldman Barrett et al., 2019). This suggests that while facial expressions certainly can, and at times do, express the felt emotions of individuals, this is but one of their functions (Hess et al., 1995; Jakobs et al., 1999; Jakobs et al., 2001). There is also evidence to suggest that contrary to Duchenne's original hypotheses, genuine smiles of pleasure and other felt emotional expressions can be produced deliberately, which hints to an additional social function of these cues (Gunnery et al., 2013; Frith, 2009; Krumhuber & Manstead, 2009; Martin et al., 2017).

However, one element missing from much of this seminal research is the dyadic social context of emotional expressions. Specifically, emotional expressions tend to occur in the context of conversations or during interactions with social partners. Thus, the removal of a social partner from studies of emotional expression favours increased experimental control over external validity (Fischer & van Kleef, 2010). Specifically, many of the early

[1] Importantly, in recent years, this has become a highly contentious assertion, with much evidence now suggesting that facial expressions may not be universally recognized across cultures (e.g., Crivelli et al., 2016; Elfbein & Ambady, 2003; Gendron et al., 2018; Feldman Barrett, 2011; Jack et al., 2012; Keltner et al., 2019)

findings in this literature are based on studies that used static photographs or video recordings of people producing emotional expressions, rather than investigating them within the dynamic social context (e.g., Dimberg, 1982; Ekman et al., 1969; Ekman & Friesen, 1971). Ultimately, this resulted in a thorough account of how facial muscles activate during the expression of "basic" emotions. However, insight from this work arose at the expense of knowledge about how these expressions, and other nonverbal behaviours, function in the naturalistic environment (Motley & Camden, 1988; van Kleef et al., 2016).

1.1.2 Behavior Ecology View of Facial Displays

In response to this criticism, researchers began to consider the social nature of emotional expressions (e.g., Fridlund 1991a; Hess et al., 1995; Jakobs et al., 1999; Jones et al., 1991). This line of inquiry resulted in a new theory, the Behaviour Ecology View of Facial Displays (BECV; Fridlund, 1991b), which contrasts the Basic Emotions Theory's (BET) claim that the primary purpose of facial expressions is to display felt emotions (Ekman, 1997). Instead, BECV posits that facial expressions are *primarily* communicative in nature (e.g., Crivelli & Fridlund, 2018; Fridlund, 1991a; Fridlund 1991b; Fridlund, 2017).

Interestingly, researchers have long argued that there are evolutionary advantages to decoding the expressions associated with the "basic" emotions proposed by BET. Specifically, displays of felt emotions have been thought to provide valuable communicative information about the immediate environment (Ekman, 1992; Ekman 1997; Hareli & Hess, 2012). From an evolutionary perspective, this information could function to bolster the fitness of our species, increasing survival efforts and the likelihood of reproduction (Tooby & Cosmides, 2008; Nakahashi & Ostsuki, 2015; Schmidt & Cohn, 2001). For instance, interpreting a look of fear directed at an element of the environment (e.g., a snake), might promote faster escape behaviour (LeDoux, 2003). Similarly, seeing disgust on someone's face after eating may indicate a spoiled or contaminated food source that one should avoid (Steinkopf, 2016; Tooby & Cosmides, 2008). Furthermore, interpreting anger during an interaction might help one predict and prepare for an upcoming altercation (Kelly et al., 2015). Indeed, there is evidence to suggest that this transference of emotional states between people, known as emotion contagion, is a valuable communicative function of felt emotions that has been associated with better group cohesion and communication (Fischer & Manstead, 2008; Spoor & Kelly, 2004).

Decoding the emotional experiences of others provides individuals with vital information on how they should respond in a particular scenario (Weber & Quiring, 2017) and prepares them to act when necessary (de Gelder et al., 2004). Specifically, research has demonstrated that emotion contagion of fear stimulates activity in the amygdala and activates the fight or flight response to prepare the brain for action (de Gelder et al., 2004; Grèzes et al., 2007; LeDoux, 1996; LeDoux 2000). This suggests that emotion contagion functions in part to foster self-protection by inducing action. When emotion contagion results in protective actions from threatening stimuli (e.g., avoiding snakes), this works to enhance survival (Keyers & Gazzola, 2021; Nakahashi & Ostsuki, 2015).

Moreover, emotion contagion has important communicative functions beyond the proposed evolutionary purposes of enhancing fitness and survival. Specifically, the information garnered from others' emotional expressions helps individuals contextualize and inform their own responses (Fuller & Sheehy-Skeffington, 1974; Ramanathan & McGill, 2007; Weber & Quiring, 2017). Furthermore, emotion contagion has been implicated in social comparisons (Gump & Kulik, 1997; Parkinson, 2011) and empathic responding (Hatfield et al., 2011; Nummenmaa et al., 2008). Importantly, the mechanisms underlying emotion contagion are multifactorial and transference depends on shared environments, consequences, and relationships dynamics between group members, suggesting that emotion contagion is socially dependent (Elfenbein, 2014).

Indeed, at its core, emotion contagion is a social process; it requires a minimum of two people, a dyad, to occur. This then begs the question of whether visible expressions primarily function to communicate emotional information to help contextualize and shape the responses of others in the social environment, instead of simply displaying felt emotions even in the absence of a social partner. If this is the case, then research should show that the presence of a social partner is correlated with emotional expressions, such that the potency of expressions and associated outcomes should differ as a function of having people nearby to interpret these cues. Interestingly, research suggests that not only is the social context and presence of others highly relevant to visible facial expressions, but it is *actually* more strongly related to these displays than the associated emotional experience itself (Fridlund, 1991; Fernández-Dols & Ruiz-Belda, 1995; Kraut & Johnson, 1979; Ruiz-Belda et al., 2003; Jones et al., 1991). For example, smiling (an expression often associated with joy) is much more likely to occur in the presence of others, even when people's feelings of experienced joy are the same across contexts (Addyman et al., 2018; Fridlund, 1991). Furthermore, the presence of others can elicit smiling even when a BET account would predict expressions associated with sadness (Schneider & Josephs, 1991), suggesting that smiling might serve to communicate the need for affiliation (Crivelli & Fridlund, 2018; Keltner & Bonanno, 1997), rather than solely the experience of happiness.

These findings are consistent with the BECV theoretical approach, which suggests that facial displays (known as emotional expression in a BET framework) do not necessarily reflect emotional experiences[2] and are instead tools for communication and social influence (Crivelli & Fridlund, 2018; Crivelli & Fridlund, 2019). Specifically, in stark contrast to the BET, BECV argues that facial displays are not about the sender's *experience*, but rather about signaling the sender's *needs* and *intentions* to elicit the desired responses from those around them (Crivelli & Fridlund, 2018). Additionally, BECV acknowledges that the communicative nature of these displays is not only contingent on the social situation (e.g., Hess et al., 1995; Jakobs et al., 1999; Jakobs et al., 2001), but that there are also both individual and dyadic differences in the way this information is communicated. For instance, regardless of the emotional experience, some people are simply more expressive than others, an individual difference that is often attributed to women (e.g., Cohn et al., 2002). Furthermore, on a dyadic level, people might want to elicit a different response depending on the person with whom they are

[2] This is not to say that they *never* reflect emotional experiences. Instead, research suggests that both play a role in facial displays, but that the communicative function is highly relevant to the social context (e.g., Hess et al., 1995; Jakobs et al., 1999; Jakobs et al., 2001)

interacting (e.g., Wagner & Smith, 1991). Indeed, people are less likely to frown, a facial display associated with seeking comfort, in the presence of a stranger compared to a friend, likely because people are less likely to seek and elicit comfort from someone they do not know (Crivelli & Fridlund, 2019; Yamamoto & Suzuki, 2006). Compared to the fixed responses associated with felt emotions that would be expected in the BET framework, this conceptualization is likely a more realistic and robust representation of how individuals use facial displays in real-world interactions.

Together, this work suggests that facial displays facilitate the communication of important information about one’s physical and social environment. Indeed, emotion contagion can provide contextual information for one’s own responses and foster understanding and support between group members (Elfenbein, 2014; Fuller & Sheehy-Skeffington, 1974; Ramanathan & McGill, 2007; Weber & Quiring, 2017). In addition to the providing information about the environment through felt emotions, facial displays also communicate important social information, such as needs and intentions (Crivelli & Fridlund, 2018). Specifically, facial displays can be seen as social tools that signal the needs and intentions of the sender (e.g., smiles demonstrating a need for affiliation) (Crivelli & Fridlund, 2018; Fridlund, 2017; Keltner & Bonanno, 1997; Mercadante et al., 2021; Schneider & Josephs, 1991; Weidman & Kross, 2021). Interestingly, a robust ability to decode the information acquired through facial displays unifies these two purposes, suggesting that there must be a process through which people acquire this savoir faire.

1.1.3 Learned Value of Facial Displays

Research and anecdotal evidence demonstrate that people robustly understand the communicative function of facial displays across interaction partners and situations (e.g., Cohn et al., 2002; Frith, 2009; Thornton & Tamir, 2017). Furthermore, within social interactions people pay special attention to facial displays (e.g., Schindler & Bublatzky, 2020), despite the availability of massive amounts of other social information, suggesting that they have exceptional informational value. There must then be a *process* through which these cues garner value so that people can reliably perceive, decode, and respond to these social signals. While some argue that this value is innate and based on evolutionary advantages (e.g., Ekman, 1992; Shariff & Tracy, 2011), what is more likely is that this is instead a learned association that has been reinforced over time, throughout varied and ongoing social interactions (Behrens et al., 2008; Feldman Barrett, 2011).

Indeed, these acquired value contingencies begin to develop and take hold in early infancy (e.g., Reeb-Sutherland et al., 2012; Thiele et al., 2021). Specifically, infants as young as three months old attend to and prefer smiles at the peak of their expression compared to non-peak smiles and neutral faces, especially when their mothers have previously used smiles as social encouragement (Kuchuk et al., 1986). This suggests that babies learn that smiling faces are rewarding, and therefore worth attending to, long before they learn many other social rules. This association continues to be reinforced throughout life, as evidence shows that smiles are used to reward "good behaviour" and frowns are used to discourage "bad behaviour" (Blair, 2003; Kringelbach & Rolls, 2003; Martin et al., 2017). This ultimately teaches people that smiles, alongside other positive cues, should be attended to (Campos et al., 2015; Pool et al., 2016) because they are highly rewarding (Averbeck & Duchaine, 2009; Clerke & Heerey, 2022; Furl et al., 2012; Heerey, 2014; Shore & Heerey, 2011). Indeed, research supports this notion, showing that people learn more efficiently when their behaviour is reinforced with genuine smiles compared to nonsocial feedback (Heerey, 2014).

However, the value acquisition for social cues is not limited to positive cues. People also learn value contingencies for cues that are associated with negative outcomes and undesirable experiences (e.g., Kringelbach & Rolls, 2003; Pollack et al., 2000; Pollack et al., 2009). For instance, research demonstrates that children who have experienced abuse are quicker to recognize the facial displays traditionally associated with anger, likely because they have learned to associate these expressions with abusive episodes (Pollak et al., 2009). Moreover, there is also evidence to suggest that less exposure to facial displays overall impairs one's ability to form both positive and negative associations. For instance, children who experience neglect, and therefore have less social exposure, show reduced recognition of expressions and delayed associative learning (Pollak et al., 2000; Wismer Fries et al., 2005). Furthermore, infants who have mothers experiencing depressive episodes (e.g., postpartum depression) show reduced attention to, recognition, and discrimination of smiling faces compared to neutral faces (Bornstein et al., 2011; Striano et al., 2002). Such data suggest that exposure to facial displays and their associated outcomes both serves to teach the communicative functions of various expressions and is an important building block for understanding social behaviour.

As social cues become repeatedly linked to significant outcomes over time, people start to attend to these stimuli more reliably (Campos et al., 2015; Pool et al., 2016). In the case of positive associations, individuals learn which cues are valuable and begin to anticipate and seek them out in hopes of a rewarding or affiliative outcome (Dewall, et al., 2009). For instance, genuine smiles are an important positive social cue that people value and seek above polite smiles and nonsocial feedback (Clerke & Heerey, 2022; Shore & Heerey, 2011), likely due to their reinforced relationship with positive social outcomes (Crivelli & Fridlund, 2018). Indeed, neutral faces that have been previously associated with genuine smiles disproportionately draw people's attention, even when it is counter-productive to task performance. For example, in a study by Heerey and colleagues (2022), participants who previously learned to associate specific faces with genuine smiles, were later significantly distracted by these faces in a visual search task. Specifically, when the neutrally posed faces that had been associated with genuine smiles were used as distractors in the task, individuals took significantly longer to find a neutral target. These findings suggest that the pull of social rewards is strong enough that smile associated faces captured attention even when the reward was no longer present.

Taken together, this collection of evidence supports an associative learning account for how social cues garner value, rather than an innate capacity to understand such cues. At a fundamental level, the value attributed to a cue through associative learning processes underpins the ability to both attend to the cue and understand its communicative intentions (Campos et al., 2015; Pool et al., 2016; Schindler & Bublatzky, 2020; Vuilleumier, 2002). At a higher level, the association between cues and their communicative functions serves to shape social behaviours by influencing anticipatory responses and moment-to-moment reactions to interaction partners' nonverbal behaviour (Behrens et al., 2009; Heerey & Velani, 2010).

1.1.4 Prediction and Coordination in Social Interactions

The processes that underpin the associative learning of social cues are important to understand because they support people's capacity to both predict and coordinate behaviour across interaction partners (Catmur & Heyes, 2018; Heerey & Crossley, 2013; Heerey & Velani, 2010; Kilner et al., 2007; Thornton et al., 2019a; Thornton & Tamir 2021a). Importantly, these proficiencies are critical for fostering smooth and fluent interactions, and thus the cognitive and neural systems that facilitate social prediction and coordination have been of particular interest to researchers. One system thought to underpin social coordination and the prediction of others' behaviour is the mirror neuron system (MNS), a network of neurons that activate similarly when observing and performing the same or similar actions (Rizzolatti, 2005; Rizzolatti & Craighero, 2004). The MNS was originally thought to facilitate the recognition and direct reproduction of actions (e.g., Buccino et al., 2004; Fadiga et al., 1995), however, it has also been implicated in understanding the intentions of others (Iacoboni et al., 2005; Rizzolatti & Sinigaglia, 2010). More recently, the MNS has been thought to play an integral role in the facilitation of short-term social prediction through associative learning processes that link related actions to one another (Catmur et al., 2007; Cook et al., 2014; Heyes, 2010; Kilner et al., 2007; Oberman et al., 2007). While scholars tend to agree that a key function of the MNS is in allowing the production of socially appropriate responses to the actions of others, there is some dissent regarding whether these responses are truly predictive or simply reactionary in nature (e.g., Hamilton, 2013).

Regardless, to support social integration, researchers have argued that the MNS interacts with other neural systems to incorporate action understanding into a more generalized system containing conceptual knowledge of actions, thereby supporting social prediction. One such integration is Theory of Mind (ToM), a cognitive model that fosters understanding of others' intentions and mental states through perspective taking (Adolphs, 1998; Gallese & Goldman, 1998; Schulkin, 2000; Schulte-Ruther et al., 2007). Indeed, ToM has been associated with both predictions of others' mental states based on knowledge of their recent experiences (e.g., Koster-Hale & Saxe, 2013; Richardson & Saxe, 2019) and in formulating appropriate responses based on those predictions (e.g., Ho et al., 2022). However, it is currently unclear how ToM accesses stored knowledge about associated actions to foster these predictions (Ho et al., 2022).

One proposition of how people can access the appropriate social knowledge among the vast cognitive space is through a network of precompiled representations (Ho et al., 2022; Morris et al., 2021). Recently, neuroscientists have proposed that the human brain has a “map” that holds category information for different types of actions, allowing people to both perceive a current action and what will come next based on the associations within and between categories (Thornton & Tamir, 2021b). Specifically, this model, known as the ACT-FAST(axonomy), has six dimensions into which the brain automatically categorizes behaviour: *abstraction, creation, tradition, food, animacy, and spiritualism*. According to this model, the closer together two actions are on the “map”, the more likely they are to precede/follow one another in an action sequence. For example, the observation that someone is cooking, precedes the prediction that they will be eating sometime soon, and that eating is more likely to follow cooking than other unrelated actions like, dancing, taking a shower, or playing a game. Indeed, the ACT-FAST model has been demonstrated to facilitate recognition of current actions and to predict several actions into the future, both generally and while making social inferences (Thornton & Tamir, 2021a; Thornton & Tamir, 2021b; Thornton & Tamir, 2022). Although the ACT-FAST model is a novel conceptualization of how the MNS might integrate with brain regions supporting memory and conceptual knowledge, it may be one explanation for how social information is accessed to make social predictions in a ToM framework. However, more empirical work is needed to investigate the link between ToM and ACT-FAST and to support these findings.

Regardless of the specifics, the existence of such systems ultimately suggests that our brains are specialized for processing and categorizing social information during a variety of different social interactions and contexts (Catmur et al., 2007; Cook et al., 2014; Oberman et al., 2007; Tamir & Thornton, 2018; Thornton & Tamir, 2021a; Thornton & Tamir 2021b). In addition, many social neuroscientists subscribe to a “predictive coding” model, which is a framework based on the assumption that the brain strives to reduce errors made in social predictions, as it does in other domains (Kilner et al., 2007; Koster-

Hale & Saxe, 2013). This is akin to the idea that people possess Bayesian-like priors about social behaviour, in which learned associations between behaviours help people to understand those around them (e.g., Kilner et al., 2007; Thornton & Tamir, 2021b). Moreover, research has demonstrated that people update their priors across different social situations (Thornton & Tamir, 2021b; Thornton & Tamir, 2022) as well as for specific interaction partners (Thornton et al., 2019b; Zhao et al., 2022), suggesting that these priors attained via associative learning processes are both flexible and continuously updated. The social predictions that result from these processes then pave the way for the production of socially appropriate and expected responses, thereby facilitating interpersonal coordination.

Convincing evidence for this idea comes in the form of anticipatory responding, which occurs when a social partner reciprocates a cue within 200ms of its onset (Heerey & Crossley, 2013). Anticipatory responses precede the reaction times necessary to process and reproduce facial expressions (i.e., mimicry), which is estimated to occur between 200ms-600ms (Achaibou et al., 2007; Dimberg & Thunberg, 1998; Hale et al., 2020). Therefore, responses that occur *prior* to 200ms *must* be made in anticipation of the cue, rather than in reaction to it (Rossion, 2014; Sanders, 1998). Interestingly, anticipatory social responding seems to particularly occur in the presence of high value cues. Indeed, people anticipate and predictively respond to social rewards similarly to the ways in which they respond to nonsocial rewards (Heerey & Crossley, 2013; Komura et al., 2001; Rademacher et al., 2009; Schultz, 2000; Sprecklemeyer et al., 2009). For instance, genuine, but not polite, smiles are more likely to be anticipated, suggesting that people have learned to predict the occurrence of a partner's genuine smiles, perhaps because of the high reward value associated with this cue (Heerey & Crossley, 2013; Shore & Heerey, 2011). Moreover, synchronous behaviours, those that co-occur with the onset of a partner's behaviour, also provide evidence of a predictive framework (Hove & Risen, 2009; Paxton & Dale, 2013a). Interestingly, as with anticipatory responding, synchrony is more likely to occur when interactions are positively valanced (Paxton & Dale, 2013a). Together, anticipatory responding and synchrony provide corroborating evidence supporting the notion that social prediction is elemental to social interactions (e.g., Kilner et al., 2007; Maranesi et al., 2014; Tamir & Thornton, 2019).

In addition to anticipatory responding and synchrony, several other social behaviours have been linked to a predictive social process. Time-sensitive matching of the same or reciprocal behaviour between interaction partners, such as direct imitation (Iacoboni et al., 1999), mimicry (Likowski et al., 2012), and complementary responses (Newman-Norlund et al., 2007; Sartori et al., 2013), have each been tied to the MNS and subsequent associative processes. Complementary responses in particular, provide evidence of higher-level functionality, such as ToM and the ACT-FAST(axonomy), because they require a conceptual knowledge of socially appropriate responses and the links between diverse types of social behaviours. Interestingly, time-sensitive matching and/or reciprocation, broadly known as interpersonal coordination, have also been thought to reinforce the stability of a social environment that is consistent with one's expectations (Behrens et al., 2008; Behrens et al., 2009). This stability may then work within a predictive coding framework to reduce prediction errors in social interactions (e.g., Genschow et al., 2018; Tamir & Thornton, 2018).

There is evidence to suggest that these hypothetical underpinnings to social behaviour may be active in the social environment. Specifically, research has demonstrated that interactions with a high degree of interpersonal coordination are more fluent and easier to predict compared to those with a lower degree of interpersonal coordination (Ackerman & Bargh, 2010; Cappella, 1985; Chartrand & Bargh, 1999; Hess, 2020; Yabar & Hess, 2007). Moreover, a recent investigation by Bachmann and colleagues (2022) demonstrates that people's capacity for social understanding and prediction diminishes when interpersonal coordination is disrupted by the artificial decoupling of social behaviours. Specifically, they report that introducing short timing delays (500ms-2000ms) between the behaviour of social partners in a recorded interaction leads to a reduced capacity to identify and contextualize facial displays (Bachmann et al., 2022), indicating that that decoupling social behaviour interferes with accurate social understanding and prediction.

Moreover, the predictive actions related to interpersonal coordination, such as anticipatory responding and synchrony, are more likely to occur in response to positively valanced social rewards (Heerey & Crossley, 2013) and interaction contexts (Paxton &

Dale, 2013a), which suggests they have an affiliative function. Indeed, interpersonal coordination has often been associated with affiliative social outcomes, such as greater levels of liking (e.g., Salazar Kämpf et al., 2017), trust (e.g., Clerke & Heerey, 2021), and better interaction quality (e.g., Mauserberger & Hess, 2019). Taken together, these findings suggest that interpersonal coordination and the proposed predictive processes thought to underpin it have important social roles that foster positive interaction outcomes through aiding in interpretation, prediction, and response formation to social behaviour.

1.1.5 Theoretical Summary

For over a century, researchers have tried to understand how people process and understand the behaviour of others and seamlessly engage in complex social interactions (Darwin, 1872; Duchenne, 1862; Dunbar et al., 2022; Ekman, 1984; Hale et al., 2020; Hess & Blairy, 2001; Hess & Bourgeois, 2010; Miles et al., 2009; Valdesolo & DeSteno, 2011). The work I've presented thus far provides key insights to these phenomena. Namely, evidence suggests that contrary to the Basic Emotion Theory hypotheses, facial displays are primarily communicative in nature and that they function as social tools to influence interaction partners to respond in desired ways (Cesario & Higgins, 2008; Crivelli & Fridlund, 2018; Fridlund, 2017; Weidman & Kross, 2021). Moreover, their forms and functions are strongly related to the presence of social partners, and perhaps less so to changes in felt emotion (Addyman et al., 2018; Fridlund, 1991; Fernández-Dols & Ruiz-Belda, 1995; Kraut & Johnson, 1979; Ruiz-Belda et al., 2003; Jones et al., 1991). Finally, I've also demonstrated that these cues gain their social value through associative learning processes, which underpin social predictions mechanisms and interpersonal coordination in interactions (Behrens et al., 2008; Catmur et al., 2007; Cook et al., 2014; Heerey & Crossley, 2013; Heyes, 2010; Kilner et al., 2007; Oberman et al., 2007; Thornton & Tamir, 2021a).

Importantly, I have focused this review on facial displays, partly because they are disproportionately represented in the published findings on nonverbal behaviour. For instance, researchers often study smiles because they occur frequently enough in naturalistic environments to be captured and studied reliably in most interactions (Crivelli

& Fridlund, 2018). However, nonverbal behaviours more generally, such as head movements (e.g., Hale et al., 2020), fidgeting (e.g., Heerey & Kring, 2007), gesturing (e.g., Cristani et al., 2013), and posture (e.g., Hagad et al., 2011), also provide valuable social information that is also used in social prediction and coordination processes.

Taken together, this work demonstrates that the capacity to fluently engage in social interactions is not a hardwired skill. Rather, it forms because of continual social exposure, learning, and reinforcement (Behrens et al., 2008; Blair, 2003; Heerey, 2014; Kringelbach & Rolls, 2003; Martin et al., 2017). Moreover, the learned associations between behaviours are the basis for accurate social prediction and fast-paced behavioural reciprocation and transitions between social partners, such as is seen with anticipatory responding, synchrony, and the other-time sensitive response patterns (e.g., imitation, mimicry, complimentary responses) that make up interpersonal coordination (Heerey & Crossley, 2013; Hove & Risen, 2009; Iacoboni et al., 1999; Likowski et al., 2012; Newman-Norlund et al., 2007; Sartori et al., 2013; Paxton & Dale, 2013a). Specifically, social responses are contingent on learned associations, both generally and on an idiosyncratic level and are thus dependent on and sensitive to the social environment (Paxton & Dale, 2017; Thornton et al., 2019a; Thornton et al., 2019b Thornton & Tamir, 2021b; Thornton & Tamir, 2022; Zhao et al., 2022).

1.2 The Segregation between Nonverbal Behaviour and its Naturalistic Social Environment

Researchers have acknowledged the social nature of nonverbal behaviour for decades (e.g., Addyman et al., 2018; Fridlund, 1991a; Heerey & Crossley, 2013; Hess et al., 1995; Jakobs et al., 1999). However, much of the published nonverbal communication literature continues to either remove or dilute the social environment inherent to the cue exchange processes (Fischer & van Kleef, 2010; Heerey, 2015). One explanation for this issue is that investigations of naturalistic interactions can be arduous. Specifically, naturalistic interactions can be difficult to capture and analyze, often requiring specialized laboratory equipment, analysis training, and software (e.g., Back & Kenny, 2010; Bernieri et al., 1994; Drimalla et al., 2019; Kashy & Kenny, 2000; Kenny & Albright, 1987; Kenny et al., 2006; Kenny & Lederman, 2010; Kyranides et al., 2022). Moreover, naturalistic interactions are by nature un-directed, meaning that they are difficult to standardize, which can weaken causal conclusions. Instead, many investigations of nonverbal behaviour have sidestepped naturalistic interactions in favour of a reductionist approach to the study of social behaviour. Even in most studies that have sought to incorporate social context, the normally highly dynamic social milieux is tightly constrained. This interferes with social prediction and coordination efforts and has negative downstream effects (Bachmann et al., 2022). These techniques, however, offer both advantages and disadvantages.

Many early studies of emotional expressions used still photographs of actors posing emotional expressions (Dimberg, 1982; Ekman et al., 1969; Ekman & Friesen, 1971). Before the wide availability of high-definition video cameras, computers, tablets, and smartphones upon which to present dynamic stimuli, this method of stimulus presentation was reasonable, especially in early studies of pan-cultural emotion recognition (Ekman et al., 1969; Ekman et al., 1987; Ekman & Friesen, 1971). This method, however, has also been used to represent social stimuli in broader contexts. For instance, still images of facial displays have been used to investigate facial mimicry (e.g., Dimberg et al., 2000; Hess et al., 2017) and emotional contagion (e.g., Nummenmaa et al., 2008; Wild et al., 2001). Because these are inherently communicative processes that function to bolster affiliation and interpersonal coordination between interaction partners, using such artificial stimuli to replace a social partner constrains genuine mimicry and naturalistic emotional contagion (e.g., Hess, 2021; Hess & Fischer, 2013; Hess & Fischer, 2022). Thus, one must wonder whether studies that use static representations of social stimuli in lieu of real social partners truly capture the social underpinnings and influences of mimicry and emotional contagion.

Another way social processes have frequently been investigated is with pre-recorded video stimuli or pre-programed avatar interactions. For instance, synchronous behaviours, such as coordinated movements, and mimicry have often been investigated using pre-recorded videos (Hess & Blairy, 2001; Lang et al., 2017; Lumsden et al., 2012; Olszanowski et al., 2019; Rychlowska et al., 2014). Moreover, mimicry has been investigated using computer programmed avatar interactions (Bailenson & Yee, 2005;

Clerke & Heerey, 2021; Hale & Hamilton, 2016; Heerey & Velani, 2010). Here, the avatars' reactions are typically programmed based on participant behaviour and/or on predetermined response contingencies (e.g., Bailenson & Yee, 2005; Clerke & Heerey, 2021; Gratch et al., 2006; Heerey & Velani, 2010). The benefit of these methods over the use of static images, however, is that participants often believe that the video is *not* pre-recorded and instead is controlled by and represents a genuine interaction partner elsewhere in the laboratory. Therefore, these methods are a proxy for social behaviour that more closely approximate social interactions compared to static social stimuli, such as photographs.

Some researchers have attempted to add the social environment back into experiments by simulating genuine social partners with confederates (e.g., Chartrand & Bargh, 1999; Lakin & Chartrand, 2003; van Baarren et al., 2004). Here, the idea is that research assistants are trained to behave in particular ways, often to create different experimental conditions. Participants are unaware of the confederate's study involvement (e.g., Chartrand & Bargh, 1999), and thus might behave as they would in a normal interaction. However, confederates are often over-trained to behave in highly invariant, experimentally relevant ways, thereby creating disfluent and unpredictable interactions. For instance, in a study by Chartrand and Bargh (1999), the investigators instructed and trained confederates to explicitly copy the nonverbal behaviour of participants, including facial expressions and postures, in the mimicry condition and remain neutral in the non-mimicry condition. In both conditions, such behaviour may defy participants' social priors. For instance, because mimicry often occurs within 600ms of a behaviour (Hale et al., 2020), it is unlikely that participants experience true mimicry, as intentional replications of behaviours are unlikely to occur that quickly. This may make a participant feel that the mimicry is mocking rather than affiliative. Conversely, in the non-mimicry condition, remaining entirely neutral in an interaction is high unusual and likely to be unsettling (Leander et al., 2012). This may then disrupt the natural social prediction and fluency of interactions, as well as increase the difficulty of generalizing conclusions to natural face-to-face social environments.

Another major concern regarding the use of confederates is that they can introduce experimenter bias into the findings (Doyen et al., 2012; Gilder & Heerey, 2018; Klintz et al., 1965). Even though confederates are usually unaware of the study hypotheses (e.g., Chartrand & Bargh, 1999), these studies cannot be double-blinded because confederates are necessarily deeply familiar with the experimental conditions. This familiarity might lead confederates to change their behaviour in subtle ways (outside of the experimental manipulation) and treat participants differently as a result (Lewis et al., 1997). Indeed, even well-meaning research assistants might behave in subtle and unconscious ways to elicit behaviours that they believe are consistent with the research questions, leading to spurious or non-replicable findings (Bargh et al., 1996; Bargh et al., 2001; Cesario, 2014; Doyen et al., 2012; Harris et al., 2013).

Thus far, I've described four ways in which researchers constrict the social environment to enhance internal validity and test causal relationships in nonverbal behaviour research, including: using still photographs, pre-recorded videos, and pre-programmed avatar interactions as stimuli, and using confederates to pose as interaction partners. Overall, the strength of these methods is that they allow for an element of experimental control that is necessarily absent from naturalistic face-to-face interactions. That is, the use of experimentally controlled stimuli ensures that all participants have the same experience within conditions, regardless of the experimenter or the qualities of their interaction partner. For instance, if a research team is interested in how anger transfers from person-to-person, using any of these methods would ensure that every participant is exposed to nonverbal behaviours that have been associated with anger, such as scowls, furrowed brows, and tense body postures (Feldman Barrett et al., 2011; Feldman Barrett et al., 2019; Kohler et al., 2004; Meeren et al., 2005). This might not be the case if the researchers opted to use a naturalistic interaction to answer this question because 1) in typical social interactions, especially those between strangers[3], anger is not as commonly expressed as more positive emotions and 2) the experimenters cannot direct the

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[3] Many of the naturalistic interactions included in social psychology studies occur between two participants who are meeting for the first time.

expression of anger in the interaction without influencing the natural flow of the conversation. Interestingly, one reason why smiles are more commonly studied in naturalistic interactions compared to other facial displays is because they appear more frequently and reliably within many types of conversations, and thus are less susceptible to the issues described above (Crivelli & Fridlund, 2018). Unfortunately, the study of many other types of social behaviour is difficult under non-experimental circumstances.

The main disadvantage of these methods is that the findings may not be generalizable to the natural social environment. The generalizability likely changes as a function of both the research question and the experimental methods used to test the study hypotheses. Indeed, some findings that have used these methods have been replicated in naturalistic settings. For instance, the literature on mimicry involving experimental methods (e.g., Clerke & Heerey, 2021; Hess & Blairy, 2001), has been replicated in naturalistic face-to-face interactions, demonstrating that people spontaneously engage in mimicry (Hale et al., 2020) and that it is linked to affiliation and positive interaction outcomes (Kurzius & Borkenau, 2015). However, many other findings, such as the "universality" of emotional expressions within and across cultures (e.g., Ekman & Friesen, 1971), have failed to replicate when seemingly minor methodological differences in stimuli or methods are employed (Gendron et al., 2018; Feldman Barrett, 2011; Feldman Barrett et al., 2011; Feldman Barrett et al., 2019; Jack et al., 2012). This indicates that although these investigations are valuable in understanding the foundations of social behaviour, they ultimately must be replicated in a social environment to enhance our confidence in their reliability and validity.

1.3 Reintroducing the Naturalistic Social Environment to Nonverbal Communication

There are many reasons why researchers have opted to remove the social environment from their investigations of nonverbal communication, such as increased experimental control. Though many of these investigations have been valuable, these findings have many shortcomings and should be validated in a naturalistic social environment. Interestingly, researchers recognize this and frequently include it as an important future direction, but this methodological limitation continues to occur (e.g., Fischer & van

Kleef, 2010; Fischer et al., 2018; Sachisthal et al., 2016), thereby limiting understanding about how social processes function in more naturalistic settings.

Social behaviour comprises the actions of not only one individual, but also of their social partners (e.g., Heerey, 2015; Kenny & Malloy, 1988; Kenny et al., 2001; Kenny et al., 2006/2020). Thus, reintroducing the naturalistic social environment to nonverbal communication research is an important endeavor. An additional challenge in doing so, however, is that research with real social partners violates an important assumption of many traditional inferential statistical techniques. Specifically, when two participants interact within the same dyad, their data are not independent of one another. Thus, an additional barrier to the study of naturalistic social behaviour is that it requires specialized analytic techniques (Kenny, 1995; Kenny & Kashy, 2000). Importantly, the empirical chapters of this dissertation include investigations of nonverbal behaviour in both dyads (Chapter 4) and groups (Chapter 3) and thus necessitate a discussion of these methods. Here, I will briefly describe the two dyadic analytic models used in this work: the Actor-Partner Interdependence Model (APIM; reported in Chapter 4) and the Social Relations Model (SRM; reported in Chapter 3).

1.3.1 Actor-Partner Interdependence Model (APIM)

Research that segregates the social environment from the study of nonverbal behaviour only focuses on one individual, and thus does not estimate the effect a social partner has on the outcomes. The Actor-Partner Interdependence Model (APIM) accounts for these influences by estimating effects for both social partners (actor and partner effects[4]) in a dyadic analysis, thus more accurately representing social interactions (Campbell & Stanton, 2015; Kashy & Kenny, 2000; Kenny et al., 2006/2020). Importantly, this analysis can be conducted for either indistinguishable (e.g., same sex friends) or distinguishable dyads (e.g., mother and child) (Boeve et al., 2019; Curran & Yoshimura, 2016; Lodder et al., 2015). Specifically, in *indistinguishable* dyads participants do not

[4] Actor and partner are arbitrary terms and are interchangeable with other terminology such as, perceiver and target. The nomenclature used depends on the study design and research questions. For instance, I use perceiver and target in Chapter 3, but actor and partner in Chapter 4.

have a pre-assigned role as they do in *distinguishable* dyads (e.g., husband/wife; parent/child; therapist/client). In other words, their assignment as “partner 1” or “partner 2” is arbitrary.

This analysis is appropriate for dyadic designs in which each member has unique scores on the same predictor and outcome variables (Kenny et al., 2006/2020). For example, the APIM might be appropriate to test the effects of smiling on an affiliative outcome, such as liking. In this case, the frequency with which each person smiled during a brief interaction could be summarized as the predictor variable, whereas each individual’s rating of how much they liked their interaction partner would be the outcome variable. The APIM estimates both actor and partner effects for dyads but does so differently depending on the distinguishability of the dyad. Specifically, if dyad members are distinguishable the actor and partner effects are estimated separately for each dyad member, resulting in four unique estimates. In the case of a mother and child dyads, there is 1) an actor effect for the mother, 2) an actor effect for the child, 3) a partner effect for the mother, and 4) a partner effect for the child. However, if dyad members are indistinguishable, the APIM estimates only two unique effects: an actor effect and a partner effect, which are estimated jointly with both partners receiving the same estimate. Because the dyads presented in Chapter 4 are indistinguishable, the remainder of this discussion will focus on APIMs with indistinguishable dyads.

For the example of smiles and liking described above, the actor effect would estimate the effect of the frequency with which Partner A (or B) smiled on their own rating of how much they liked their partner. This is represented in the solid lines in Figure 1-1. The partner effect, on the other hand, estimates the effect of the frequency with which partner A (or B) smiled on how much they were liked by their partner (i.e., their partner's rating). This is represented as the dashed lines in Figure 1-1. Beyond the main actor and partner effects, APIMs can also estimate between-dyad covariates and within-dyad covariates. Specifically, between-dyad covariates are those in which both dyad members have the same score, such as the number of years the dyad members have been friends, whereas within-dyad covariates are those in which dyad members might not have the same score, such as age or a specific personality trait. The APIM can be estimated with both multilevel and structural equation models (Campbell & Stanton, 2015; Kenny et al., 2006; Stas et al., 2018). In Chapter 4, I use a structural equation modelling approach.

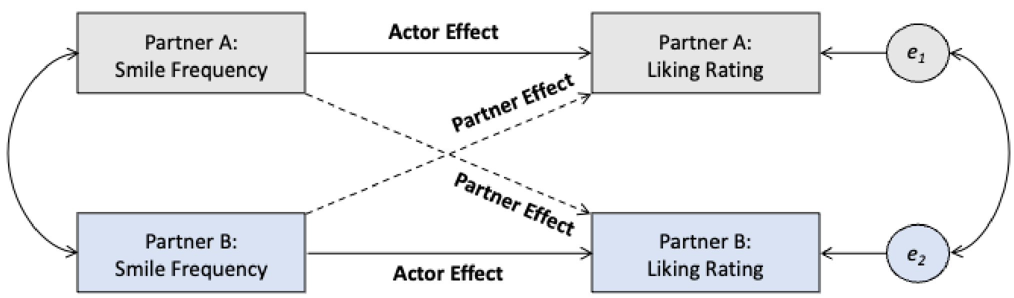

Figure 1-1 General Actor-Partner Interdependence Model (APIM)

A pictorial representation of the APIM with indistinguishable dyads. Actor effects are shown with solid lines from Partner A's smile frequency to Partner A's liking rating and from Partner B's smile frequency to Partner B's liking rating. In this case, the actor effect is the estimate of how much their own smile frequency influenced how much they liked their partner. Partner effects are shown with dashed lines from Partner A's smile frequency to Partner B's liking rating and from Partner B's smile frequency to Partner A's liking rating. In this case, the partner effect is the estimate how much their own smile frequency impacted how much they were like by their partner. Because these are indistinguishable dyads, both the actor and partner effects are the same for Partner A and Partner B.

1.3.2 Social Relations Model (SRM)

Like the Actor Partner Interdependence Model (APIM), the Social Relations Model (SRM) is an analytic technique used to estimate the actor and partner effects in dyads. Where it differs, however, is that it is meant to be used in group settings, in which each person is a member of more than one dyad (Back & Kenny, 2010; Kenny & La Voie, 1984; Kenny et al., 2006/2020). This also allows for the estimation of relationship effects, which evaluate how specific combinations of actors and partners influence ratings. These settings are frequently conceptualized as "round robin" designs in which each participant might interact dyadically with each other group member in turn.

For instance, Salazar Kämpf and colleagues (2017) used a SRM with indistinguishable dyads to investigate the effects of mimicry on liking in a round robin design. Here, participants had a 5-minute interaction with each other person before providing liking ratings. An individual's behaviour in the interaction is the predictor variable and liking ratings for each person is the outcome variable. These designs are most appropriately analyzed with an SRM to account for the fact that each person is a member of more than one dyad (Table 1-1). The SRM, like the APIM, can account for indistinguishable dyads (e.g., a group of same sex friends) and distinguishable dyads (e.g., family members). In Chapter 3, I conducted a modified version of the SRM to account for having a categorical, rather than a continuous, outcome variable (Hoff et al., 2020).

Traditionally, APIMs and SRMs have been considered advanced analytic techniques, which required specialized skills and software to conduct, such as Soremo (Kenny, 1998a), Blocko (Kenny, 1998b), and Proc Mixed in SAS (Campbell & Kashy, 2002). More recently, free and open-source analysis software, such as JASP and R, have made dyadic data models more accessible. Indeed, many R packages facilitate the use of these models, including srm (Nestler et al., 2019), TripleR (Schönbrodt et al., 2022), rSiena (Ripley et al., 2022), and amen (Hoff et al., 2020). While these packages are freely available, and often have excellent documentation, their implementation requires at least some basic coding skill. However, the need for coding skills has been substantially diminished by the development of several dyadic analysis Shiny apps, which are user-friendly, web-based graphic user interface created in R. Specifically, Kenny and colleagues have published and maintain several Shiny apps to conduct APIMs and SRMs, including those that allow for mediation and moderation in either structural equation (e.g., Stas et al., 2018) or multilevel modelling frameworks (e.g., Kenny, 2015). A full list, including detailed descriptions, of these Shiny apps is available on Professor David A. Kenny's website (https://davidakenny.net/DyadR/DyadRweb.htm). Importantly, these apps have significantly reduced the accessibility concerns associated with dyadic analysis because they require little coding skill and only a basic theoretical understanding of the models. Although naturalistic interaction researchers still face the challenges associated with research design and data collection, the ease with which one can now conduct dyadic analyses has significantly reduced one challenge associated with this work.

Table 1-1 Round-Robin Design for Social Relations Modelling (SRM)

	Partner				
Actor	1	2	3	4	5
1	-	3	6	3	1
2	5	-	6	5	7
3	4	5	-	5	6
4	3	4	7	-	5
5	1	5	6	4	-

Note. Data is fabricated for demonstration purposes. Here, the actor is represented in the rows and their partner is represented in the columns. For instance, the first row of the table demonstrates person 1's rating of all their interaction partners. The grey squares are intentionally uncollected self-rated data, whereas the coloured squares represent scores on the outcome variable; specifically, red squares represent low scores, yellow square represent neutral scores, and green squares represent high scores. In this example, there is clear evidence of an actor effect for person 2, in that they rate everyone highly. Likewise, there is a clear partner effect for person 3. That is, they are rated highly by their peers, even the ones who rate everyone else poorly.

1.4 Current Research Summary

The empirical research presented in the following chapters emphasize many features of nonverbal behaviour, including the value of social rewards (Chapter 2), social perception and interpersonal accuracy (Chapter 3), and interpersonal coordination (Chapter 4). Specifically, in Chapter 2, I investigate the impact of the saliency of a recent conversation or social media post on the value of social and monetary rewards, using highly constrained, experimental stimuli. This study examines how a more distal social context might alter reactions to specific social cues. In Chapter 3, I investigate how people use social signals and nonverbal cues to make social judgements about others by examining their ability to make inferences about other participants' behaviours. Finally, in Chapter 4, I investigate the effects of interpersonal coordination on liking and interaction quality in naturalistic face-to-face and video call (i.e., Zoom) conversations and compare the effects across interaction modalities. Importantly, all three empirical chapters include elements of real interactions and social behaviour and thus work to reintroduce the naturalistic social environment to research on nonverbal cues and communication.

Chapter 2

2 The Impact of Social Media Saliency on the Subjective Value of Social Cues[5]

Regardless of race, age, gender, or socioeconomic status, social media has become omnipresent in people's lives with about 72% of North Americans reporting that they are social media users (Pew Research Centre, 2021; Statistics Canada, 2021). One reason for its popularity is that it targets people's need for social connection and desire to build social relationships (Ahn, & Shin, 2013; Sheldon, et al., 2011). Indeed, social media has extended the capacity for human social connection by allowing people to establish, maintain, and promote social ties in situations where face-to-face interactions are not possible.

Despite its utility, there is ongoing debate regarding the consequences of social media use (e.g., Huang, 2020; Liu et al., 2019). On the one hand, social media enhances wellbeing by allowing people to focus on social connection and building and maintaining relationships (Burke & Kraut, 2016; Clark et al., 2018; Deters & Mehl, 2014; Lee et al., 2013; Liu & Yu, 2013; Marzouki et al., 2021; Verduyn et al., 2017; Wenninger et al., 2019). This is especially true when people receive positive feedback that aligns with their expectations (Greitemeyer et al., 2014; Grinberg et al., 2017; Valkenburg et al., 2006). On the other hand, there is concern that frequent use may cause social withdrawal (Kraut, et. al., 1998), addictive behaviour patterns (Hou et. al., 2019), and decreased wellbeing (Kross et al., 2013). Specifically, a focus on the passive consumption of others' content (Liu et al., 2019; Tosun & Kasdarma, 2020; Verduyn, et al., 2015; Verduyn et al., 2017) and/or negative feedback that poorly aligns with expectations may lead to problematic outcomes (Greitemeyer et al., 2014; Grinberg et al., 2017; Valkenburg et al., 2006)

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One reason for social media's ubiquitous influence may be that it activates reward circuitry in the brain (Meshi et al., 2015) similarly to face-to-face interactions (Sherman et al., 2018). For example, in face-to-face interactions, people find social cues such as smiles and praise to be highly rewarding (Bhanji & Delgado, 2014; Furl et al., 2012; Hammerschmidt et al., 2018; Shore & Heerey, 2011; Zernig et al., 2013). Likewise, broadcasting and observing information, giving and receiving feedback, and comparing oneself to others also trigger reward networks (Fareri & Delgado, 2014; Meshi et al., 2015). Thus, interacting on social media may be intrinsically rewarding.

One difference between the rewards obtained on social media and those associated with face-to-face interactions is their timing. Specifically, rewards in real-time conversation occur immediately and predictably (Heerey & Crossley, 2013), whereas rewards on social media are delayed by pseudorandom time increments. Specifically, people must revisit a social media post for anticipated likes, shares, and comments, which are variably delayed depending on when followers respond. This delay might affect reward responsiveness. For example, dopamine neurons in many brain regions are sensitive to reward timing and predictability (e.g., Ballard & Knutson, 2009; Bermudez & Schultz, 2014; Estle et al., 2007; Kabel & Glimcher, 2007; Roesch et al., 2007; Wanat et al., 2010). Dopaminergic responses to unpredictable and delayed rewards subsequently shape how those rewards are experienced (Berns et al., 2001; de Lafuente & Romo, 2011), potentially leading to reward sensitization (Berridge & Robinson, 2016; Hellberg et al., 2019; Konova et al., 2018). Thus, social media use may sensitize the reward system to the presence of social rewards, thereby enhancing their value. Accordingly, for some people social media use is associated with heightened sensitivity to reward magnitude and reduced sensitivity to risk (Meshi et al., 2019; Meshi et al., 2020).

If social media use does indeed affect people's sensitivity to social rewards, at least temporarily, we would expect people actively considering a recent social media post and the social feedback they have received to show heightened incentive salience (i.e., wanting; Berridge, 2007) and sensitivity to social rewards, relative to those considering a recent face-to-face conversation. Indeed, the "social snacking" hypothesis (Gardner et al., 2005) is well aligned with this idea. Specifically, people seek out makeshift ways to satisfy their need for social connection when they cannot engage in meaningful interactions. Because these proxy interactions are less adept at satisfying social connection needs (Gardner et al., 2005), they may enhance social reward seeking (Baumeister & Leary, 1995; Krämer et al., 2018). Thus, while social media is momentarily rewarding it may fail to fulfill social connection needs.

2.1 Current Research

The current research addresses this possibility by investigating whether the salience of social media use influences the subjective value of social rewards. We operationalize social rewards with images of genuine smiles, which differ in form and function from polite smiles. Genuine smiles activate the orbicularis oculi and zygomaticus major muscles, whereas polite smiles only activate the latter (Ekman et al., 1990; Ekman et al., 2002; Frank et al., 1993). Genuine smiles convey the presence of positive emotion in senders and elicit the same in receivers (Ekman, 1992; Ekman et al., 1990; Ekman & Friesen, 1982; Geday et al., 2003; Gunnery & Hall, 2015; Surakka & Hietanen, 1998). In addition, genuine smiles are perceived more positively than polite smiles in both real conversations and laboratory tasks (Averbeck & Duchaine, 2009; Gunnery & Ruben, 2015; Heerey & Crossley, 2013; Scharlemann, 2001; Shore & Heerey, 2011). Polite smiles, in contrast, are important social tokens, but do not tend to be associated with positive affect or social reward (Ambadar et al., 2009; Bogodistov & Dost, 2017; Martin et al., 2017).

Here, we ask whether thinking about a recent social media post impacts the subjective utility of social rewards by examining the degree to which participants are willing to give up monetary for social rewards and how these findings compare with thinking about a recent synchronous conversation. Importantly, we only ask about the incentive saliency (i.e., wanting) of social rewards and not their hedonic value (i.e., liking), which is thought to be independent (Berridge, 2007; Tindell et al., 2009). In two studies, we expect that individuals who are currently thinking about a recent social media post will demonstrate greater subjective utility for genuine smiles, compared to those who have posted recently but are not specifically thinking about their post and to those who held a real-time conversation. Exploratory analyses examine the impact of overall social media use on the utility of social rewards, and whether results are moderated by need to belong (Knowles et al., 2015).

2.2 Study 1

2.2.1 Methods

2.2.1.1 Participants

Participants were recruited for the study on Prolific Academic in exchange for £2.50 GBP, as well as a small performance-based monetary bonus. We estimated a required sample size of 412 participants using a G*Power analysis for a MANOVA (global effects model) with 4 groups and 3 response variables (Faul et al., 2007). Estimate parameters included alpha=.05, 1-β=.90, and estimated effect size $f^2(V)$=.01626 (based on Pillai V=.048), based on pilot study data (see Supplementary Materials). Knowing that we would need to delete cases due to data quality issues, we recruited a sample of 441 participants, for this online study. We subsequently excluded 21 participants for inattentive and/or invariant responding. Inattention was classified as responding faster than 225ms on at least 40% of trials and invariant responding was classified as responding with the same response option on 90% or more of trials. We also removed one statistical outlier (+4.5 SDs from the mean of genuine smile utility)[6]. Our final sample included 420 participants (235 male, 6 nonbinary; Mage=32.94, SD=11.26). All participants gave informed consent and the University's Ethics Committee approved all study procedure (likewise for Study 2).

2.2.1.2 Procedures

After participants consented, they received a message asking them to either make a post on their preferred social media platform or have a "face-to-face conversation with a friend". Participants in the conversation condition were told that due to pandemic restrictions, they could have their conversation over a video-chat application (e.g., Zoom,

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[6] In both studies, statistical outliers were classified as +/-4.5SDs from the mean of the subjective value of monetary rewards, polite smiles, and/or genuine smiles.

FaceTime) if necessary. Approximately 24 hours later, they received a reminder to complete the post or conversation and a link to the study. The link opened a Qualtrics survey (https://qualtrics.com) that randomly assigned them to either answer questions about their post/conversation before the smile valuation task (https://pavlovia.org) or immediately afterwards.

2.2.1.2.1 Smile Valuation Task.

This task has two phases, an exposure phase, in which participants learned to associate both a monetary and a social value with each of six computerized players, and a test phase, in which they used this information in the context of a choice task. On each exposure trial, participants viewed one player, depicted by a photograph of an actor in a neutral pose, in the center of the screen. Flanking the actor on either side, participants saw images of the heads and tails side of a coin (Figure 1a). Participants attempted to guess the side of the coin the player had chosen on that trial. Participants received immediate feedback from the player about whether their choices were correct. Specifically, they were told that some of the players would smile to show a correct response, and some would give text feedback. They also knew that each time they

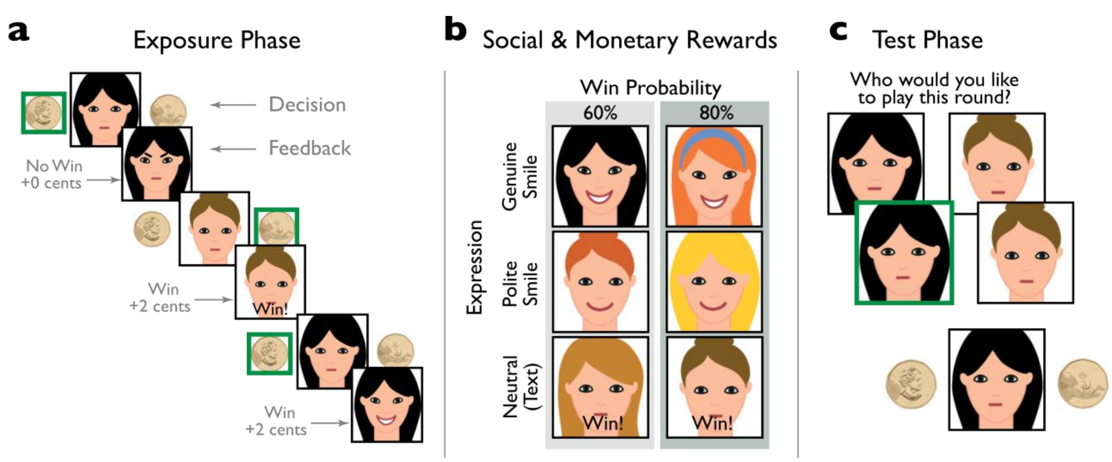

Figure 2-1. Smile Valuation Task

a) Exposure phase in which participants learned to associate players with social and monetary outcomes. b) Social and monetary reinforcements across the face set (the dark-grey background tile indicates high monetary value, and the light grey tile indicates low monetary value). c) Test phase in which participants selected a player before playing each round. In the game participants played, they viewed real photographs of faces rather than cartoons.

received “correct” feedback they earned a small financial bonus ($0.02GBP, which they would receive at the end of the study.

In reality, feedback was not associated with participants’ choices in the exposure phase. Instead, three players provided rewards on 80% of trials and the remaining players provided rewards on 60% of trials, regardless of participant’s choices (see Figure 1b). In addition, two players (one 80% player and one 60% player) provided reward feedback by smiling genuinely at participants, two players smiled politely at participants (one 80% and one 60% player), and the remaining players’ feedback was presented with a text overlay that displayed the trial outcome value (“Win!”; “Non-win.”). The four players who had smiled to indicate reward feedback indicated non-reward feedback with lowered eyebrows, whereas those that had provided text feedback remained in the neutral pose throughout the trial. There was no response time limit on the trials and feedback lasted 1.5 seconds. To ensure that specific player-value pairings did not systematically affect the outcome, the computer randomly assigned players to both monetary and social feedback conditions at the start of the task. Half the participants, randomly assigned, viewed female faces and half viewed male faces. Participants completed 120 exposure trials, 20 trials per player, in a fully randomized order. Participants had a rest break after each block of 40 trials.

Once participants had completed the exposure phase of the task, they began the test phase. Test trials began with a choice (Figure 1c). Participants viewed a pair of neutrally posed players and selected the one they wanted to play on that trial. Thereafter, trials continued as in the exposure phase. Participants chose between all possible player pairs (15 possible pairings) in random order. Each possible pairing appeared eight times (120 test-trials). Within pairings, each face appeared on the left and the right sides of the screen with equal frequency.

Participants’ decisions in the test phase (which player they selected, given the monetary and social values of the players within a pairing) served as the dependent variable in the task. These choices allowed us to estimate how much genuine and polite smiles and monetary feedback shaped choice behaviour. For example, participants with a strong affinity for genuine smiles might prefer a genuinely smiling player with a lower monetary value over a higher monetary value neutral player. In other words, a participant's choice behaviour allowed us to quantify the extent to which that participant was willing to sacrifice the chance to earn money for the chance to see a genuine smile. This value indicates the subjective utility of genuine smiles in monetary terms for that participant (see Heerey & Gilder, 2019; Shore & Heerey, 2011). Here, we are interested in the utility of genuine smile, polite smile, and monetary feedback, and how these change as a function of social media saliency.

2.2.1.2.2 Smile Stimuli

Smile stimuli in the task were obtained from 20 male and 20 female, 18- to 24-year-old actors. To elicit polite smiles in a video-recorded procedure, actors watched an experimenter pose the smile and imitated the action. Genuine smiles were elicited using an emotion induction paradigm. All actors reported experiencing positive emotion during the selected genuine smiles. Still photos were clipped from the peak of each expression. We recorded a minimum of five polite and five genuine smiles per actor. These were validated in a subsequent pilot study in which 88 participants discriminated genuine from polite smiles across the set of 400 photographs. Actors and images were selected such that the smiles were discriminable by at least 70% of the sample.

2.2.1.2.3 Salience Manipulation.

Either immediately before, or immediately after completing the smile-valuation task, participants answered a set of questions regarding their social media post or conversation. For example, those who posted on social media were asked to reflect on the type of post they had made and how it had been received (e.g., "how many likes/comments did you receive?" and "to what extent was the feedback that you received positive?"), whereas those who had a conversation were asked to reflect on their experience talking to a friend (e.g., "the conversation made me feel positive" and "the quality of the conversation met my expectations"). These questionnaires (along with the rest of the study materials, data, and analysis code) are available on the Open Science Framework (osf.io/db2j9). The primary purpose of these questionnaires was to manipulate post/conversation saliency by calling the relevant interaction to mind. Participants in the post-task saliency conditions answered the questions for completeness after the smile valuation task.

2.2.1.2.4 Questionnaires

After completing the smile valuation task and answering questions specific to their post/conversation, participants completed a modified version of the Social Networking Time Use Scale (SONTUS; Olufadi, 2016), which measures social media use in different contexts to generate an estimate for how much time an individual spends on social media. For our purposes, we used a shortened version of the original questionnaire that consisted of 19 items (e.g., "*when watching TV*", "*when you are shopping*", "*when you are at work*") measured on a 5-point scale ranging from 1 ("*Never in the past week in this situation/place*") to 5 ("*I used it every time I was in this situation/place during the past week*").

Participants also answered questions about their general social media use. For instance, we asked how frequently participants logged onto social media platforms and how frequently they posted. These items served to gauge participants' typical social media usage. Finally, they responded to the Big Five Inventory (John & Srivastava, 1999) and the Need to Belong Scale (Leary et al., 2013) to explore relationships between task variables and extraversion and need for social belonging.

2.2.1.3 Data Analysis

To examine the degree to which social and monetary rewards shape choice behaviour within the smile valuation task, we individually modeled each participant's choices using a logistic model. The model estimated the probability that a participant would select the face on the left ($P_{Left\ Face}$), given relative differences in the type and frequency of social and monetary rewards within the face pairing. We used a standard logistic model to fit the choice data:

$$P_{Left\ Face} = \frac{\exp(\theta)}{(1 + \exp(\theta))}$$

The parameter θ in the logistic regression was estimated as:

$$\theta = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

In this equation the βs are the estimated regression weights for each term in the model. β_0 refers to the intercept; β_1 is the degree to which monetary rewards influenced choice behaviour; β_2 is the degree to which genuine smiles influenced choice behaviour; and β_3 estimates the influence of polite smiles on choice behaviour. The Xs in the equation represent the difference between the player on the left and the player on the right. X_1 codes the difference in the expected monetary value (the probability of winning money multiplied by the amount of a win; i.e., 1.6 cents for the 80% faces versus 1.2 cents for the 60% faces) between the players within a pair. For example, X_1 received a score of .40 if the player on the left rewarded more frequently. X_1 received a score of -.40 if the player on the right had higher monetary value. If both players had the same monetary value (e.g., a pair of 80% players), X_1 was equal to 0. X_2 coded for genuine smiles such that if the face on the left smiled genuinely and the face on the right did not, X_2 received a score of 1. If the smiles were reversed, X_2 was coded as -1. If both or neither face smiled genuinely, X_2 was coded as 0. X_3 coded for the presence of polite smiles in similar fashion.

The model used an iteratively re-weighted, least squares algorithm to obtain the maximum likelihood estimate for each of the terms (O'Leary, 1990). Importantly, we determined the model coefficients on a participant-by-participant basis because that allowed us to ask whether participants for whom the social media post was salient showed enhanced sensitivity to social rewards, in the context of general individual variability in social reward utility. The model coefficients for each participant became the dependent variables in the hypothesis tests below. Insofar as a model coefficient differs from 0, that model term influences choice behaviour.

2.2.2 Results and Discussion

Before testing our hypotheses, we conducted a 2x2 ANOVA to test for group differences in social media use. There were no significant effects of interaction type (social media vs conversation; $F(1,416)=3.30$, $p=.070$, $\eta_p^2=.008$), saliency (pre- vs post-task;

F(1,416)=0.58, *p*=.447, η_p^2=.001), or their interaction (*F*(1,416)=3.48, *p*=.063, η_p^2=.008). Likewise, there were no group differences in terms of how frequently participants logged on to social media sites, the positivity of feedback they receive, or how satisfied they are with the feedback they receive (Table 2-1).

Table 2-1 Study 1 group differences in social media use and feedback.

	Frequency of Logging onto Sites				
	df	SS	F	*p*	η_p^2
Interaction Type	1	2.31	1.84	.176	.005
Saliency	1	0.10	0.08	.783	< .001
Interaction Type x Saliency	1	3.58	2.85	.092	.007
Residuals	391	491.77	-	-	-
	Feedback Positivity				
	df	SS	F	*p*	η_p^2
Interaction Type	1	20.49	0.06	.805	<.001
Saliency	1	76.45	0.23	.634	<.001
Interaction Type x Saliency	1	27.41	0.08	.775	<.001
Residuals	391	131598.00	-	-	-
	Feedback Satisfaction				
	df	SS	F	*p*	η_p^2
Interaction Type	1	120.97	0.28	.600	<.001
Saliency	1	458.88	1.05	.307	.003
Interaction Type x Saliency	1	328.95	0.75	.387	.002
Residuals	390	171137.69	-	-	-

To test whether social media and conversation saliency influenced the subjective value of social and monetary rewards, we conducted a 2x2 MANOVA with saliency (pre-task, post-task) and interaction type (social media, conversation) as fixed factors and the individually estimated regression weights for monetary rewards, polite smiles, and genuine smiles as the dependent variables. The multivariate tests for the interaction condition (social media vs conversation) and saliency (pre- vs post-task) and their interaction were all significant (Table 2-2). There were no significant main effects or interactions for monetary rewards or polite smiles (Table 2-3). However, there were significant main effect of interaction type (*F*(1,416)=12.78, *p*<.001, η_p^2=.03) and saliency (*F*(1,416)=7.07, *p*=.008, η_p^2=.02) and a significant interaction (*F*(1,416)=6.09, *p*=.014, η_p^2=.02) for the value of genuine smiles (Figure 2-2).

Table 2-2. Study 1 multivariate tests for the effects of Interaction Type, Saliency, and their interaction on the value of genuine smiles, polite smiles, and monetary rewards.

	df	Approximate F	Pillai's Trace	*p*
Intercept	3, 414	130.03	0.49	<.001
Interaction Type	3, 414	5.74	0.04	<.001
Saliency	3, 414	4.05	0.03	.007
Interaction Type x Saliency	3, 414	2.78	0.02	.041

Table 2-3. Study 1 univariate results for the effects of Interaction Type, Saliency, and their interaction on the value of monetary rewards and polite smiles.

	Monetary Rewards					Polite Smiles				
	df	SS	F	*p*	η_p^2	df	SS	F	*p*	η_p^2
Intercept	1	327.16	290.99	<.001	.412	1	50.16	26.14	<.001	.059
Interaction Type	1	0.47	0.42	.520	<.001	1	5.59	2.91	.089	.006
Saliency	1	2.51	2.23	.136	.005	1	4.06	2.11	.147	.005
Interaction Type x Saliency	1	0.18	0.16	.693	<.001	1	2.39	1.24	.265	.002
Residuals	416	467.71	-	-	-	416	798.20	-	-	-

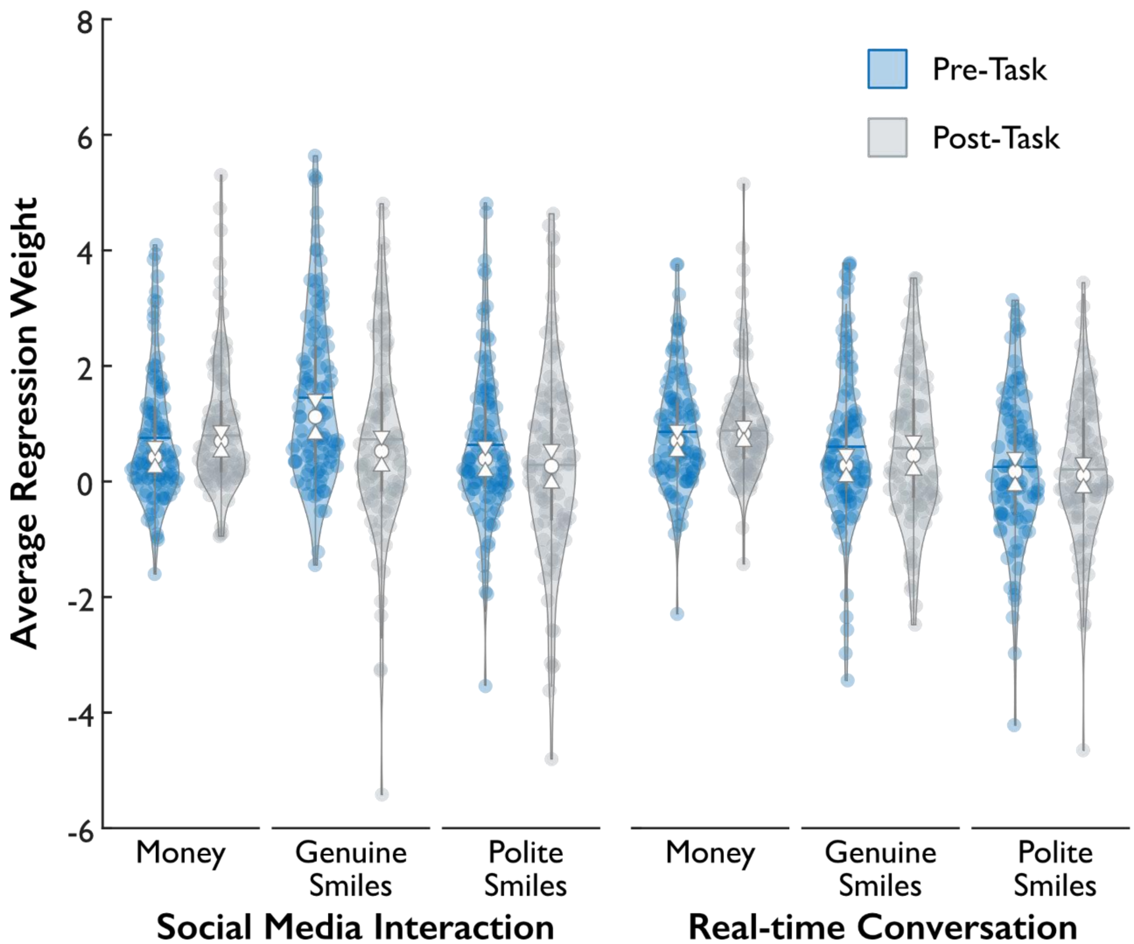

Figure 2-2. Study 1 Results.

The value of money, genuine smiles, and polite smiles in the pre-task and post-task conditions for participants who made a social media post (left set of violins) versus had a real-time conversation (right set of violins). Blue fill represents participants in the pre-task condition and grey fill represents participants in the post-task condition. Within each violin, white dots represent the median and the white notches represent the 95%CI of the median; the horizontal lines show the means; the dark grey bars represent the interquartile range (IQR); and the light grey lines represent 1.5 times the IQR. The shape of the violin shows the probability density function of the data distribution. Individual data points are shown with coloured dots.

Consistent with expectations, a post-hoc Tukey test revealed that those in the pre-task social media condition valued genuine smiles more highly than did individuals in any other condition (post-task social media: $M_{Difference}$=.72, 95%CI[.208,1.23], t=3.63, p_{Tukey}=.002; pre-task conversation: $M_{Difference}$=.85, 95%CI[.334,1.362], t=4.25,

p_{Tukey}<.001; post-task conversation: $M_{Difference}$=.87, 95%CI[.363,1.384], t=4.41, p_{Tukey}<.001).

Figure 3, included for descriptive purposes, shows how participants in each condition made decisions, given the relative differences in reward type and frequency within a given pair. For example, all participants preferred high- to low-value faces; and participants in the social media salient (pre-task) condition preferred the genuinely smiling player, even when that choice was associated with financial loss.

We also conducted exploratory tests to investigate possible moderators of the relationship between social media saliency and genuine smile value. Previous

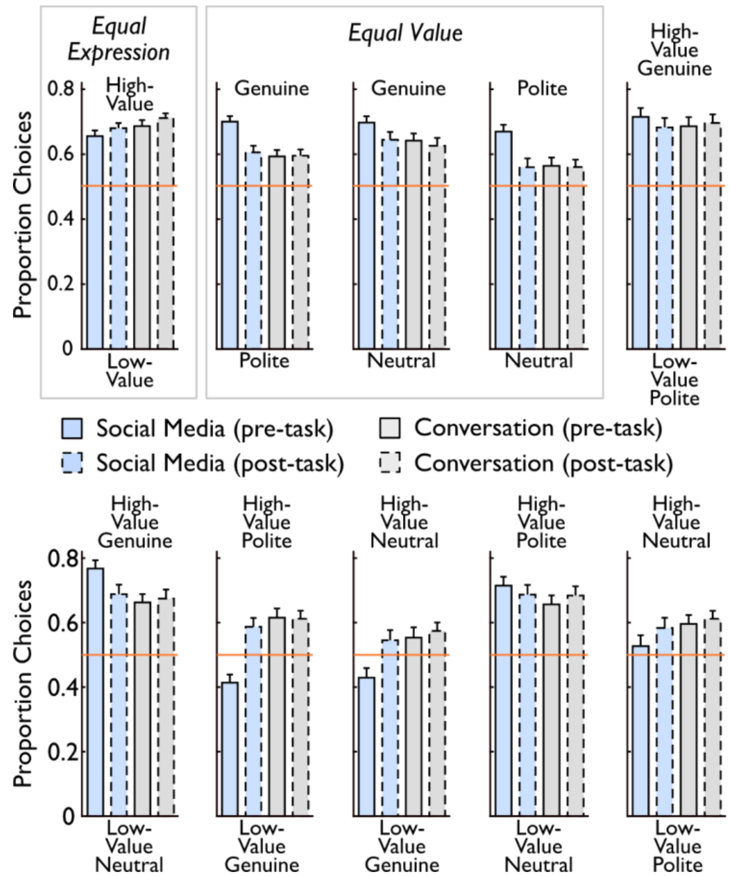

Figure 2-3. The proportion of choices participants allocated to a particular face, given relative differences in reward type and frequency within a given pair in Study 1.

The orange reference lines indicate indifference between the faces in the represented pairing (50%). Bars with values greater than 50% of choices indicate a preference for the stimulus listed at the top of the column, bars below these lines indicate a preference for the face listed at the bottom of the column. The "Equal Expression" plot shows choices collapsed across expression for faces of different values (e.g., a high-value vs a low-value politely smiling face). The "Equal Value" plots show choices collapsed across value for the different expression pairings (e.g., a high-value genuine face versus a high value polite face). The remaining plots show choices in which the faces within a pairing differed on both monetary and social value. Error bars show +/-1SEM.

research has shown that need to belong is predictive of social media use (Knowles et al., 2015) and although we found evidence of this association, it did not affect the relationship between the genuine smile utility and social media saliency (see Appendix B for a detailed description of these analyses). Together, these results suggest that social media saliency is the important factor in these results and that the mere saliency of social interaction, as measured in the conversation condition does not appear to promote this effect. To corroborate our findings, Study 2 is a pre-registered replication and extension of Study 1 that allowed us to rule out several alternate explanations for these results (osf.io/db2j9).

2.3 Study 2

2.3.1 Methods

2.3.1.1 Participants

Participants were recruited for the study on Prolific Academic in exchange for £3.00 GBP and a small performance-based monetary bonus (£1.00-£2.00 GBP). We used G*Power to conduct an ANOVA fixed effects, special, main effects, and interactions power analysis, with an estimated effect size f=0.196, alpha=.05, 1-β=0.95, numerator df=1, and groups=4 (Faul et al., 2007). According to this analysis we would need 341 participants to achieve 95% power. However, because this is a replication of Study 1, in which we collected 440 participants before exclusions, we aimed to collect 440 participants (actual N=442) for Study 2 rather than the 341 suggested by the power analysis. We excluded 20 participants for inattentive and/or invariant responding and one participant who was a statistical outlier (+4.5SDs from the mean of monetary reward utility)[7]. Our final sample included 421 participants (187 males, 7 nonbinary; M_{age}=38.26, SD=12.64).

[7] The decision to exclude this participant from the analyses was not pre-registered, however it does not change the interpretation of the findings.

2.3.1.2 Procedures

Participants completed the same procedure as above with several additions. We included the Revised UCLA Loneliness Scale (Russell et al., 1980), post-game ratings of each player examining how "good" they were to play (1=worst to play; 6=best to play), and a smile discrimination task in which participants viewed photos of smiling faces (including the faces they viewed in the task) and identified whether each smile was genuine or polite. Finally, we included a short manipulation check at the end of the study in which participants estimated the frequency of their conversations and social media posts in the past 48 hours, rated these for positivity and satisfaction. They also rated the degree to which they had had a conversation and social media post on their mind when they began the main task.

2.3.1.3 Results and Discussion

As in Study 1, we conducted a 2x2 ANOVA to test for group differences in social media use prior to testing our hypotheses. There were no significant effects of interaction type ($F(1,416)=.99$, $p=.321$, $\eta_p^2=.002$), saliency ($F(1,416)=0.14$, $p=.707$, $\eta_p^2<.001$), or their interaction ($F(1,416)=2.73$, $p=.099$, $\eta_p^2=.007$) on overall social media use. There were also no significant group differences in terms of how frequently participants logged on to social media sites, feedback positivity, or satisfaction with feedback (Table 2-4). Manipulation check data showed that participants who answered questions pre-task reported thinking a lot about their post or conversation (depending on the condition) and less about the other condition, whereas those in the post-task conditions were less occupied with the post or conversation (Table 2-5). These results suggest that our manipulation had its intended effect.

Table 2-4. Study 2 group differences in social media use and feedback.

	Frequency of Logging onto Sites				
	df	SS	F	*p*	η_p^2
Interaction Type	1	0.29	0.29	.590	<.001
Saliency	1	0.16	0.17	.683	<.001
Interaction Type x Saliency	1	1.75	1.78	.182	.004
Residuals	416	407.30	-	-	-
	Feedback Positivity				
	df	SS	F	*p*	η_p^2
Interaction Type	1	67.99	0.21	.648	<.001
Saliency	1	14.97	0.05	.830	<.001
Interaction Type x Saliency	1	86.33	0.27	.607	<.001
Residuals	416	135617.11	-	-	-
	Feedback Satisfaction				
	df	SS	F	*p*	η_p^2
Interaction Type	1	4.64	.01	.929	<.001
Saliency	1	0.23	<.001	.984	<.001
Interaction Type x Saliency	1	15.36	0.03	.871	<.001
Residuals	416	242159.52	-	-	-

Table 2-5 Manipulation check for social media versus conversation saliency.

		Conversation in mind		Social media post in mind	
Interaction Modality	Salience	Mean	SD	Mean	SD
Social Media	Pre-Task	22.664	28.315	37.645[b]	35.578
	Post-Task	23.991	30.613	24.924	28.923
Conversation	Pre-Task	45.942[a]	34.885	23.030	28.606
	Post-Task	26.125	27.843	19.825	26.264

a. Differs from all other column means p<.001 (Bonferroni corrected)
b. Differs from all other column means p<.0135 (Bonferroni corrected)

We then tested our hypothesis using a 2x2 MANOVA with the individualized regression weights for monetary rewards, polite smiles, and genuine smiles as the dependent variables and interaction type (conversations, social media) and saliency (pre, post) as the independent variables. The multivariate tests for the interaction condition and saliency and their interaction were all significant (Table 2-6). Follow-up investigations of the univariate tests revealed that there were no significant main effects or interactions for monetary rewards, whereas the value of polite smiles was only influenced by saliency, such that those in the pre-task conditions valued polite smiles more than those in the post-task conditions ($M_{Difference}$=.29, 95%CI[.049,.538], t=2.36, p_{Tukey}=.019, η_p^2=.013)(Table 2-7). Because polite smiles are important social cues, this finding is consistent with the notion of increased desire for social rewards, however, because it was not statistically significant in Study 1, we do not discuss it further.

Table 2-6 Study 2 multivariate tests for the effects of Interaction Type, Saliency, and their interaction on the value of genuine smiles, polite smiles, and monetary rewards.

	df	Approximate F	Pillai's Trace	*p*
Intercept	3, 415	156.12	0.53	<.001
Interaction Type	3, 415	6.76	0.05	<.001
Saliency	3, 415	3.88	0.03	.009
Interaction Type x Saliency	3, 415	6.47	0.05	<.001

Table 2-7 Study 2 univariate results for the effects of Interaction Type, Saliency, and their interaction on the value of monetary rewards and polite smiles.

	Monetary Rewards					Polite Smiles				
	df	SS	F	p	η_p^2	df	SS	F	p	η_p^2
Intercept	1	304.48	294.99	<.001	.414	1	72.30	44.44	<.001	.096
Interaction Type	1	0.18	0.17	.677	<.001	1	1.43	0.88	.348	.002
Saliency	1	0.54	0.53	.468	.001	1	9.15	5.62	.018	.013
Interaction Type x Saliency	1	1.91	1.85	.175	.004	1	5.91	3.63	.057	.009
Residuals	417	430.42	-	-	-	417	678.48	-	-	-

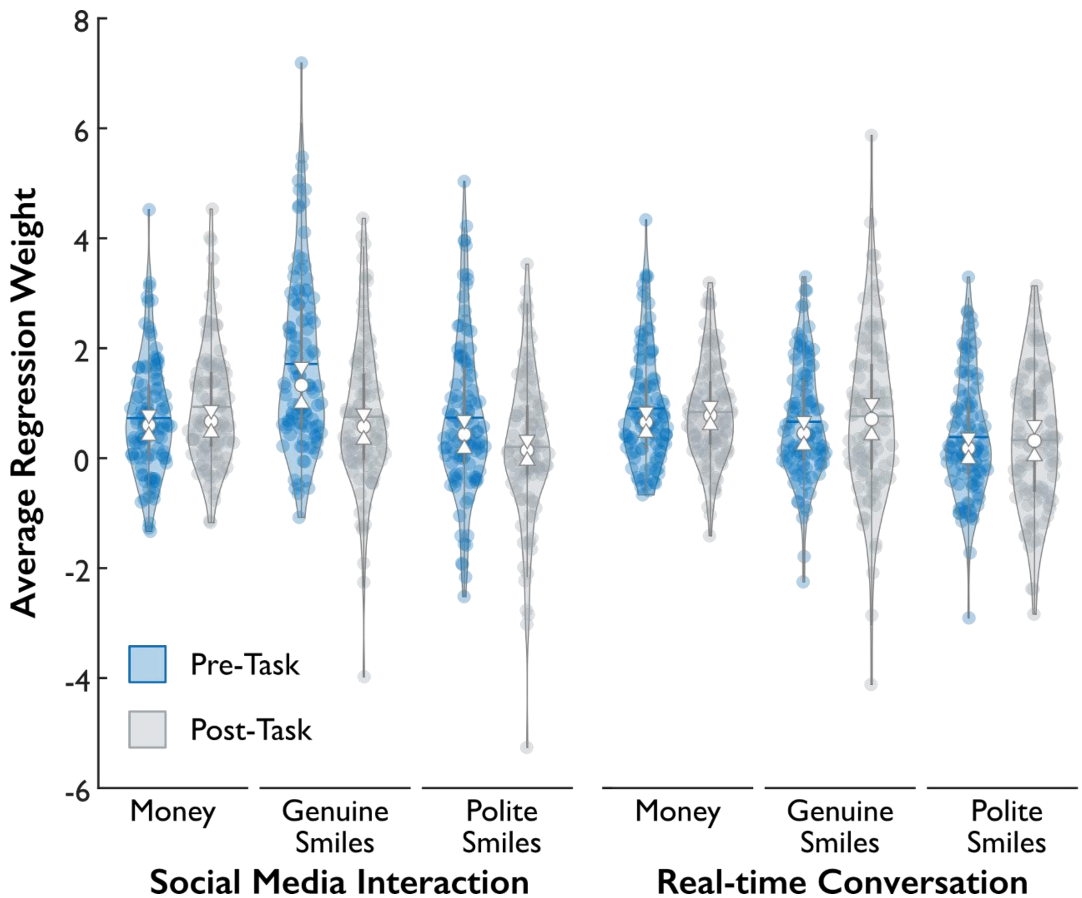

Figure 2-4 Study 2 Results.

The value of money, genuine smiles, and polite smiles in the pre-task and post-task conditions for participants who made a social media post (left set of violins) versus had a real-time conversation (right set of violins). Blue fill represents participants in the pre-task condition and grey fill represents participants in the post-task condition. Within each violin, white dots represent the median and the white notches represent the 95%CI of the median; the horizontal lines show the means; the dark grey bars represent the interquartile range (IQR); and the line grey lines represent 1.5 times the IQR. The shape of the violin shows the probability density function of the data distribution. Individual data points are shown with coloured dots.

Genuine smile utility, however, was significantly influenced by interaction type (F(1,417)=15.37, p<.001, η_p^2=.035), saliency (F(1,417)=10.48, p=.001, η^2 =.024), and their interaction (F(1,417)=15.62, p<.001, η_p^2=.036)(Figure 2-4). Consistent with expectations, a post-hoc Tukey test revealed that those in the pre-task social media condition valued genuine smiles more than those in any other condition (post-task social media: $M_{Difference}$=.96, 95%CI[.473,1.448], t=5.08, p_{tukey}<.001; pre-task conversation:

$M_{Difference}$=1.05, 95%CI[.564,1.539], t=5.56, p_{tukey}<.001; post-task conversation: $M_{Difference}$=.95, 95%CI[.463,1.440], t=5.02, p_{tukey}<.001).

Figure 2-5 describes participants' decisions strategies across the player pairs for visualization. Figure 6 shows participants' explicit ratings of the faces across conditions. We expected that participants in the high social media saliency condition would rate genuinely smiling faces as "better" compared to other participants. To examine this, we conducted a saliency (high/low) x interaction-type (social media/conversation) x monetary value (high/low) mixed ANOVA, with ratings of the high- and low-value faces as the dependent variables (Table 2-8). Importantly, the interaction-type x saliency interaction was significant, showing that participants in the high social media saliency condition rated genuinely smiling faces more highly than any other group (post-task social media: $M_{Difference}$=.49, 95%CI[.084,.903], t=3.19, p_{tukey}=.008; pre-task conversation: $M_{Difference}$=.57, 95%CI[.169,.988], t=3.75, p_{tukey}=.001; post-task conversation: $M_{Difference}$=.52, 95%CI[.115,.936], t=3.40, p_{tukey}=.004). A similar analysis involving politely smiling faces showed no significant interaction (Table 2-8).

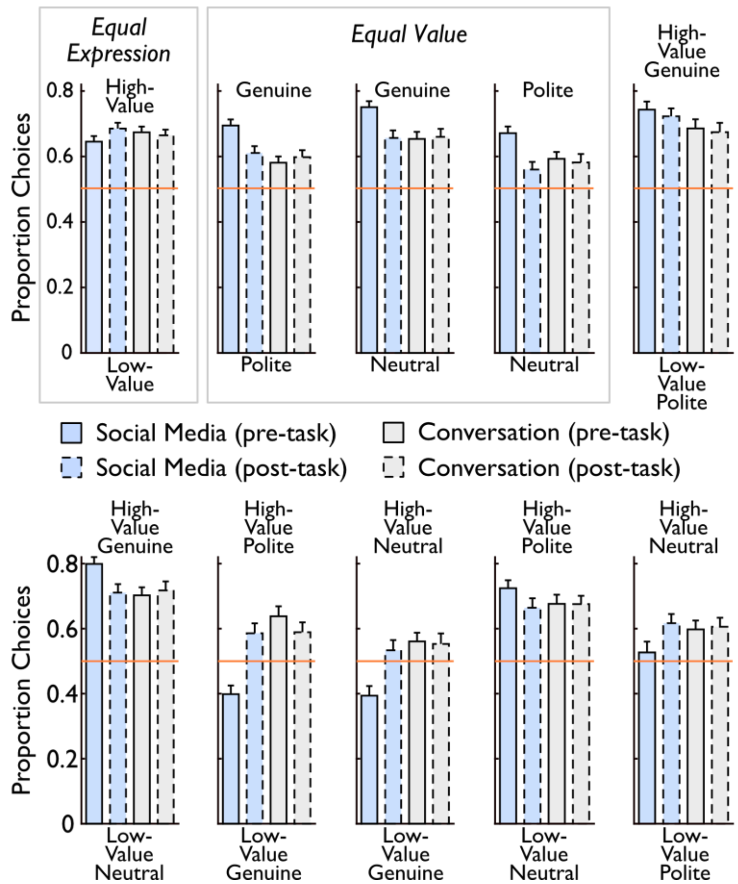

Figure 2-5 Study 2 Choice Behaviour

The proportion of choices participants allocated to a particular face, given relative differences in reward type and frequency within a given pair in Study 2. Error bars show +/-1SEM.

Table 2-8 Mixed-ANOVA Results for Explicit Ratings of Genuinely and Politely Smiling Faces

	Genuinely Smiling Faces					Politely Smiling Faces				
	df	SS	F	p	η_p^2	df	SS	F	p	η_p^2
Monetary Value	1	284.53	129.66	<.001	.237	1	364.81	173.44	<.001	.294
Interaction Type	1	19.67	7.78	.006	.018	1	3.47	1.81	.179	.004
Saliency	1	10.19	4.03	.045	.010	1	1.08	.57	.453	.001
Interaction Type x Saliency	1	15.71	6.21	.013	.015	1	0.04	.021	.884	<.001
Monetary Value x Interaction Type	1	9.21	4.20	.041	.010	1	5.53	2.63	.106	.006
Monetary Value x Saliency	1	2.33	1.06	.03	.003	1	8.44	4.10	.046	.010
Monetary Value x Interaction Type x Saliency	1	6.832	3.11	.078	.007	1	6.025	2.87	.091	.007
Residuals	417	1054.22	-	-	-	417	877.10	-	-	-

We conducted exploratory analyses to investigate possible moderators of this effect. We found no significant moderators of this relationship. However, we did find that need to belong correlated significantly with social media use and that active forms of social media use were associated with decreased loneliness. None of these findings were related to genuine smile utility (for a detailed report, see Appendix B).

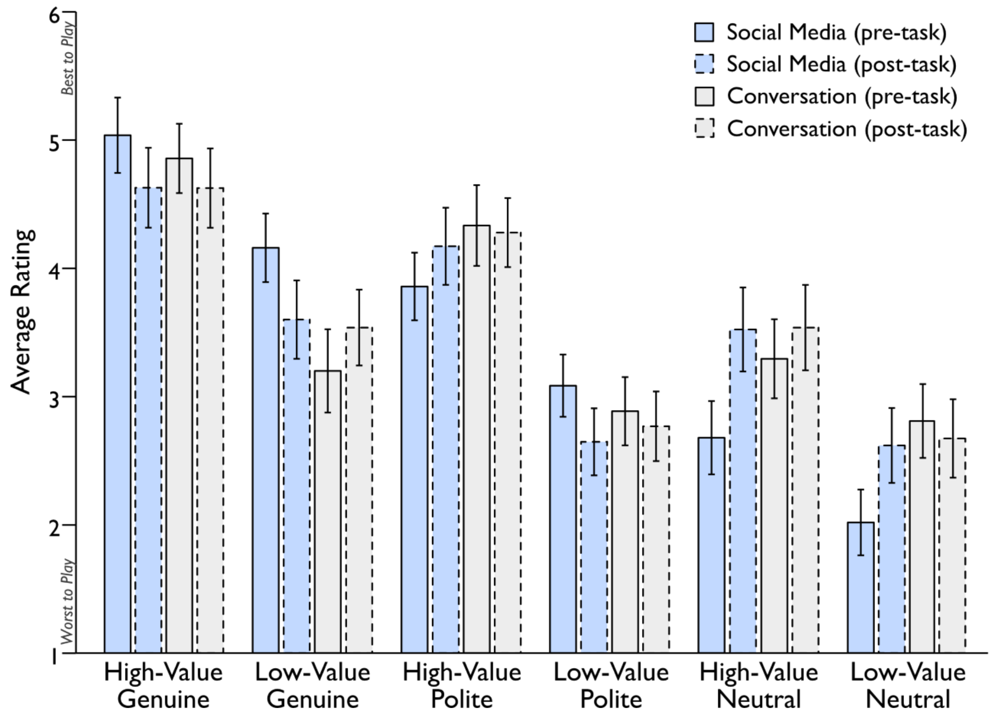

Figure 2-6 Player Ratings Across Groups.

Average ratings of how good each player was to play. Error bars show 95%CI.

2.4 General Discussion

Results from these studies suggest that individuals for whom social media use is salient demonstrated greater subjective desire for genuine smiles than did those for whom social media use was not currently in mind. Indeed, across both studies, participants in the high social media saliency condition were willing to give up an average of .85 cents (SD=.82) per trial, relative to their peers in the other conditions (mean=.32 cents/trial, SD=.63). They also rated genuinely smiling players more favourably than did other participants (Study 2). Furthermore, individuals who answered questions about a real-time conversation before versus after the smile valuation task did not differ in the extent to which the possibility of seeing genuine smiles shaped their choice behaviour, meaning that this effect is driven by social media saliency, rather than the simple act of making a social media post or thinking about social interactions more generally. This idea is consistent with research showing that reward context modulates subjective reward utility (Louie & Glimcher, 2012).

These results suggest that, when salient, social media interactions increase the subjective utility of social rewards to a greater degree than salient face-to-face conversations. Participants' choice behaviour in the subsequent task demonstrated the enhanced incentive salience (Berridge, 2007) of social rewards. This finding may explain why people find it difficult to stop scrolling a social media feed once they get started and why cues that enhance the salience of social media (e.g., alerts from social media apps) may pull people to return to it.

As we have suggested throughout this paper, social media use and its effects on people's wellbeing is controversial (e.g., Clark et al., 2018; Hou et al., 2019; Knowles, et al., 2015; Lee et al., 2013). Here, we asked participants to focus on the more interactive outcomes of social media (likes, shares, and comments), rather than on the experience of social connectedness per se. This focus might have heightened social reward salience in the present participants. Future research should seek to disentangle the influence of these specific outcomes from a focus on general social connectedness, which may be more sustaining.

This work, however, is not without limitation. First, although we discuss the effects of social media on social reward utility, stimuli in the smile valuation task (photographs of smiling actors) are limited in their ability to serve as real-world social rewards. Indeed, it is unlikely that photos of smiling faces are as powerful as the smile of a friend in a face-to-face interaction. Second, although we tried to make the questions assessing the social media post and the conversation as similar as possible, subtle differences in the outcomes of these interaction modalities may have affected task results. Third, our study design does not allow strong conclusions about the mechanism responsible for this effect. For example, social media saliency may stimulate a need for social connection (Clark et al., 2018), thereby sensitizing people to social reward cues. Alternately, as we have suggested, the timing of reward delivery (Kabel & Glimcher, 2007) may be the central factor driving this result. Future work should seek to disentangle these effects by manipulating both feelings of social connectedness and reward delivery. Finally, we make no inferences about the longevity of this effect. Because data were collected at a single time point, it is unclear how long social media salience enhances desire for social reward.

2.5 Conclusions

Taken together, our findings suggest that when social media use, but not social interaction more generally, is salient, people show enhanced utility for social rewards. Although we did not examine this specifically, social reward saliency may have subsequent consequences for outcomes such as mood and behaviour. It is likely the case that this effect plays a role in explaining the persistence and popularity of social media. It may also provide a partial explanation for prior reports noting divergent outcomes of social media use (e.g., Burke et al., 2010; Clark et al., 2018; Seabrook et al., 2016). Finally, this finding suggests that one way to reduce the pull of social media, might be to make alerts, followers, and feedback less salient, thereby reducing people’s desire to engage in this domain.

Chapter 3

3 Nonverbal Behaviour as Social Signals: The Role of Movement in Interpersonal Accuracy

The ability to accurately perceive and understand another person's intentions is an important social skill. Specifically, interpersonal accuracy has been linked to more fluent interactions because individuals who are adept at this skill can better predict, adapt, and respond appropriately to a social partner's behaviour (Palese & Schmid Mast, 2020; Schmid Mast & Hall, 2018). This leads to better interaction outcomes for dyads, including more liking and better interaction and relationship quality (Hall et al., 2009; Human et al., 2013; Human, 2020; Neff & Karney, 2005). Furthermore, interpersonal accuracy has been positively related to other social competencies, including better nonverbal decoding skills and higher levels of empathy and emotional intelligence (Hall et al., 2009).

Given the importance of interpersonal accuracy, understanding how individuals verge on accurate judgements is a prominent area of research. A popular approach has been to investigate differences between individuals with high perceptive accuracy, or those who are generally proficient at interpersonal perceptions, and those with low perceptive accuracy (e.g., Biesanz, 2010; Biesanz, 2018; Christiansen et al., 2005; Funder, 1999; Ekman & O'Sullivan, 1991; Hall et al., 2009; Ickes, 1993; Ickes et al., 2005; Kenny & Albright, 1987; McLarney-Vesotski et al., 2011). This work has identified several characteristics that are positively related to perceptive accuracy, such as social competence and knowledge, empathy, and extraversion (e.g., Hall et al., 2009; McLarney-Vesotski et al., 2011). However, despite common characteristics associated with "good judges", perceptive accuracy is also context dependent, meaning that individuals are not necessarily consistent across ratings of different categories of information (e.g., behaviour, personality, emotions; Boone & Schlegel, 2016; Hehman et al., 2017; Schlegel et al., 2017). Furthermore, the practical importance of being a "good judge" might be limited because, across contexts, perceptive accuracy hinges on the quality and quantity of available information about the target (Rogers & Biesanz, 2019). In other words, for one to be accurate in their judgements, a “good target” is needed.

A “good target”, or one who is high in expressive accuracy, is defined by being, on average, easier to evaluate leading to more accurate judgements from others (Biesanz, 2010). The variance between individuals in expressive accuracy is relatively stable across contexts and can be broadly explained by individual differences in psychological adjustment, social status, and socialization (Human & Biesanz, 2013; Human et al., 2019; Human et al., 2021). Pertinently, expressive accuracy has been linked to skills learned through socialization, including a robust ability to both encode and decode nonverbal social cues (Human & Biesanz, 2013; Latif, et al., 2021). Interestingly, these findings have also been tied to extraversion, partially because extraverts may demonstrate more unambiguous nonverbal behaviour, which is easier to decode and categorize (Ambady & Rosenthal, 1998; Gross & John, 2003; Human et al., 2021; Riggio & Riggio, 2002).

The finding that individuals signal their inner states and traits through their nonverbal behaviour has inspired another prominent area of research in interpersonal perception. Specifically, because skillful encoding of nonverbal behaviour is related to accurate perception, researchers have sought to identify a process by which people decode this information. One simple explanation comes from the theory of direct social perception, which suggests that through perception alone, individuals can identify others’ internal states, intentions, and beliefs because they are outwardly displayed in behaviour (Gallagher, 2008; Gallagher & Hutto, 2008; McNeil, 2012; Spaudling, 2015). In other words, according to this perspective, certain states and intentions have a behavioural signature that signals that the state is active in the target (Krueger, 2018). For instance, in the context of perceiving deception, researchers have attempted to identify relevant cues that are present when someone is lying. The goal of such research has traditionally been to pinpoint a set of cues that are universally present in the context of telling a lie, such as averting eye contact (Vrji et al., 2001; Wright Whelan et al., 2013) or an increase in fidgeting (Fielder & Walka, 1993; Porter et al., 2010). However, research has generally failed to find evidence to support the idea that accurate perception is based on a distinctive set of cues that uncover a target’s intentions, be it in the context of lie detection (DePaulo et al., 2003; Hartwig & Bond, 2014; Luke, 2019) or person perception more generally (Hall et al., 2019).

One reason these explorations have proven futile is that they often remove the context of social cues, instead focusing on a singular cue or information pathway. This methodology assumes a non-inferential model with 1:1 mapping of behaviour to intentions, states, and/or traits where social cues can be accurately interpreted independently from the broader social context (Brunet et al., 2009; Wiltshire et al., 2015). However, direct social perception requires the broader context to be in place to foster accurate judgements. Specifically, the assumption that inner states and intentions have undeviating and measurable indicators that are consistent across individuals, situations, and social contexts has not generally been supported by research (e.g., Carrad, 2021; Feldman Barrett, 2006; Feldman Barrett et al., 2011; Feldman Barrett et al., 2019; Vinciarelli et al., 2012). Instead, research finds that there are individual differences in how people behave and respond to situations, suggesting that inner states may not be signaled or interpreted consistently across individuals (Bem & Allen, 1974; Feldman Barrett et al., 2019; Hall et al., 2019; Levine et al., 2011; Schlegel et al., 2020; Vrij et al., 2019). Furthermore, behaviour and cues are highly context dependent and fluctuate as a function of interaction-based variables (Back & Kenny, 2010; Carrad, 2021; Heerey, 2015; Kenny, 2019; Kenny & Albright, 1987), including power dynamics between social partners (Hall et al., 2006) and the closeness of the relationship (Kenny & Acitelli, 2001). Indeed, the individual differences in perceptive and expressive accuracy demonstrate these idiosyncrasies and suggest the need for a more complex paradigm.

A more reliable criterion might be social signals more generally, which are the amalgamation of several social information pathways (Vinciarelli et al., 2019). Instead of relying on one type of information, such as facial expression alone, to understand inner states and traits, social signals consider the broader context of concurrent cues (Brunet et al., 2009; Vinciarelli et al., 2012; Vinciarelli et al., 2019). For instance, when perceiving someone who is smiling, proponents of 1:1 non-inferential mapping would conclude that this person is happy. Although this might be true, considering other cues, such as posture, proximal distance, and gestures, would provide additional information, thereby enhancing the accuracy of such an inference (Levine, 2015; Poggi & D'Errico, 2012; Vinciarelli et al., 2012).

Broadly speaking, nonverbal social signals come in the form of facial and body language, most of which are comprised of subtle movements (Brunet et al., 2009). Because social signals are incredibly complex and multifaceted, one way of incorporating them into analytic models is to amalgamate the signal into a quantification of movement (e.g., Lu et al., 2005). Indeed, research that has investigated movement, rather than static cues, has found that individuals are able to use this information to make accurate inferences about their interaction partner's states, traits, and intentions (e.g., Atkinson et al., 2004; Becchio et al., 2012; Manera et al., 2011; Obhi, 2012; Sartori et al., 2011).

Compared to non-inferential models, social signals provide a more robust framework for understanding the behaviour of others, partly because they consider that cues do not unilaterally signal one meaning. However, this also introduces an aspect of uncertainty and inaccuracy to interpersonal judgements, suggesting that accurate interpersonal perception hinges on a predictive social inference model rather than a non-inferential model (Catmur, 2015; de Bruin & Strijbos, 2015; Moutoussis et al., 2014b). Pertinently, there is substantial evidence to support the existence of predictive social processes (e.g., Joiner et al., 2017; Moutoussis et al., 2014a; Tamir & Thornton, 2018; Thornton & Tamir, 2021).

Despite the uncertainty and potential for error inherent to a predictive social inference model, people are relatively proficient at making social judgements. Researchers have suggested that this process might occur through associative learning and "predictive coding" (Catmur et al., 2007; Cook et al., 2014; Heyes, 2010; Kilner et al., 2007; Oberman et al., 2007). Specifically, people's brains are specialized for processing and categorizing social behaviour throughout an interaction (Thornton & Tamir, 2021) and for using learned associations between social signals to understand and make predictions about other people's future behaviour and intentions (Catmur et al., 2006; Heyes, 2010; Tamir & Thornton, 2018; Tenenbaum et al., 2006; Thornton et al., 2019a; Thornton & Tamir, 2021b). In other words, we learn to predict others' behaviour based on Bayesian-like priors of associated signals, both about social interactions generally (Thornton & Tamir, 2021b) and about our interaction partners specifically (Thornton et al., 2019b; Zhao et al., 2022).

Consistent with this idea, is the finding that people tend to make more accurate judgements about those with whom they are more familiar (Carney et al., 2007; Connelly & Ones, 2010; Elfenbein & Ambady, 2003; Eveland & Hutchens, 2013; Funder & Colvin, 1988; Hofer et al., 2022; Thomas & Fletcher, 2003; but see Gagné & Lydon, 2004 for an argument which suggests that familiarity may also breed biased perceptions). Furthermore, many investigations of interpersonal accuracy rely on the ratings of friends, romantic partners, or family members as the criterion used to determine accuracy, suggesting that many experts believe that close others are more capable of accurate perception compared to relative strangers (e.g., Kim et al., 2019; Rogers & Biesanz, 2019; Vazire & Carlson, 2011). From a predictive social inference perspective, this suggests that through ongoing exposure, people likely update their inference information on person-by-person basis with familiar others having a more robust network of prior information compared to strangers (Kilner et al., 2007; Moutoussi et al., 2014b). However, much of the research on person perception focuses on first impressions from relative strangers (e.g., Latif et al., 2021; Olivola & Todorov, 2009) and does not account for baseline information, repeated exposure, or the importance of individualized priors (Bond & DePaulo, 2006; Vrji, 2016). Therefore, we do not have a robust understanding of how individuals use social signals over time to make inferences about other people's inner states, traits, and intentions.

3.1 Current Research

The current research addresses this gap by investigating the inferences people make about a social partner's intentions over time. My research design allowed me to investigate both within- and between-subject factors related to interpersonal accuracy because participants made judgements about four peers at three-time points, with access to baseline behaviour. Specifically, participants in this study interacted with one another in a 5-minute unscripted interaction prior to playing 3 rounds of a "hidden role" game, in which participants attempt to guess others' roles while concealing their own. I captured social signals in the form of general movement (e.g., fidgeting, gesturing, posture changes) in an unscripted social interaction and across the three game rounds. Importantly, incorporating individualized movement patterns across tasks encapsulates a predictive coding model because it accounts for learning idiosyncrasies of individuals' behaviour across scenarios, allowing the updating of priors and social knowledge accordingly.

I operationalize an individual's baseline movement as their average movement from frame-to-frame in the initial unscripted 5-minute interaction, and changes from baseline as the difference between each round's average movement and a participant's baseline (a participant's baseline movement, subtracted from their movement in a round). I then ask whether changes from baseline movement in each round would predict the judgements individuals made about their peers. In this case, an accurate judgement was operationalized as correctly guessing the hidden social role of the target. I expected that positive changes from baseline (i.e., greater movement) would lead to more accurate judgements from their peers. In line with research suggesting that individuals high in extraversion are more adept at encoding nonverbal behaviour (e.g., Human et al., 2021), I expected that target extraversion would also predict judgement accuracy.

Finally, I anticipated that familiarity would play a role in accuracy. Specifically, I expected that accuracy would increase across rounds, with judgements in the third round being more accurate, on average, than those in earlier rounds. Because the length of each round was variable, depending on overall group behaviour, this analysis accounted for the fact that some groups had more information on which to base their inferences. Here, I anticipate that longer than average round lengths will correlate with greater interpersonal accuracy.

3.2 Methods

3.2.1 Participants

Participants were recruited from a psychology undergraduate research pool in exchange for partial course credit. Participants also received raffle tickets based on game performance for the chance to win one of three $50 gift certificates to the University

Bookstore. I planned to collect 250 participants (50 groups of 5) however, data collection was stopped prematurely due to safety protocols associated with the onset of the COVID-19 pandemic. As a result, the final sample included 115 undergraduates in 23 groups of 5 (36 males, M_{age}=18.51, SD=2.22). All participants gave informed consent and the University's Ethics Committee approved all study procedures.

3.2.2 Procedure

3.2.2.1 General Overview

Participants arrived at the lab in groups of five for a study about "cue exchange in a naturalistic game". Once all participants arrived for the session, they were invited to the lab space, which housed 5 partitioned computers and a round table. After the consent procedure, participants completed the Positive and Negative Affect Schedule[8] (PANAS; Watson, Clark, & Tellegen, 1988) and were then asked to proceed to the game table. Importantly, participants received a study moniker that was displayed at the computer terminals and the table so that participant data could be easily linked throughout the course of the study.

Once all participants completed the PANAS, they engaged in a 5-minute unscripted interaction in which they were asked to get-to-know one another. All interactions from this study were video recorded for offline behavioural analysis. After the 5-minute interaction, the experimenter introduced the game, which is based on a popular board game called The Resistance (Eskerage, 2009). To enhance memory for game roles, I reimagined the theme of the game to correspond to a popular young adult fantasy series, Harry Potter (Rowling, 1999), with which most undergraduate students are familiar. This game was chosen because it is a hidden role game, in which players must conceal their identities to achieve a win for their team. This concealment allows me to make inferences about individuals' capacity to use the behaviour of their peers to detect their intentions. Participants played three independent rounds of this game with game roles randomly assigned at the start of each game (Figure 3-1a). In between game rounds, participants

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[8] The PANAS was included for an honours' thesis project and was not analyzed in this dissertation.

returned to their computers to respond to a questionnaire about the game play during that round. After the final round, participants also completed several mood and personality measures, including the Big Five Inventory (John & Srivastava, 1999)[9]. Finally, they completed a video consent form that asks about further use of their video data (Appendix C) before being thanked and dismissed.

3.2.2.2 Game Play

Participants played three independent rounds of a Harry Potter themed hidden-identity game. The game consists of two teams, Dumbledore's Army (DA; three players) and the Death Eaters (DE; 2 players), who compete in 'battle rounds.' The first team to win three battles wins the game. The DE have the advantage of knowing each other's identity, whereas the DA only know their own role and are trying to guess other player's roles throughout the game.

At the start of the first game, the experimenter assigned the player immediately to their left to be the team leader (Figure 3-1b). This role then rotated clockwise on a round-by-round basis, continuing in between games. The team leader's objective was to assign either two or three players (round dependent) to go "on battle". The participants who were chosen to go on battle were given a wand token so they could be easily identified by the remainder of the group (Figure 3-1c). The whole group then voted to "accept" or "reject" the chosen battle team. If the team was accepted, then the battle started, otherwise the leader token moved to the next player, and they were then tasked with choosing a new team. Importantly, if a group failed to organize a team after five attempts, the DE automatically won the battle.

Once the chosen battle team was approved, the team members were dealt a "pass" card and a "fail" card by the experimenter (Figure 3-1d). The team members then secretly decided which card to play by placing it face down on the play mat (their discarded card was placed face down in a discard pile, so their choice remained a secret). If the entire team played the "pass" card, then the DA won the battle, however if one "fail card" was

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[9] The remainder of the mood and personality measures were not analyzed within the context of this study.

played, then the DE won the battle (Figure 3-1e). Importantly, DA members were required to play the “pass” card, whereas the DE could choose to strategically play either the “pass” or the “fail” card. For DE members to increase their likelihood of winning the game, they must play a “fail” card, however, there are instances in which this may not the strategic choice. For instance, a DE player may have chosen to play a “pass” card if they were attempting to convince the other players that they were a loyal DA member (see Figure 3-1 for a pictorial overview). The first team to win three battles, wins the game. To incentive performance in the game, players on the winning team received a raffle ticket for the prize draw.

At the beginning of each of the three games, participants were randomly dealt a role card that either placed them on the DA or the DE. They were instructed to memorize their role and place their card in an opaque envelope to hand to the experimenter. The experimenter only opened the envelopes to record the participant roles once each game had ended, meaning that the experimenter was blind to group membership during game play. Importantly, because roles were assigned anew for each game, some participants had experience playing as both roles by the end of the study session. This allows for a not only a between-subjects analysis of interpersonal accuracy, but also a within-subjects analysis of behaviour change associated with the different roles.

Once participants knew their roles, the experimenter guided them through an exercise allowing the DE members to learn one another’s identity while the DA (and the experimenter) remained blind to others’ roles. Here, the experimenter instructed everyone to close their eyes, then asked the DE to open their eyes and find one another. After waiting approximately 5 seconds for the DE to locate each other, they instructed the DE to close their eyes, before instructing everyone to open their eyes. After this brief exercise, the game began.

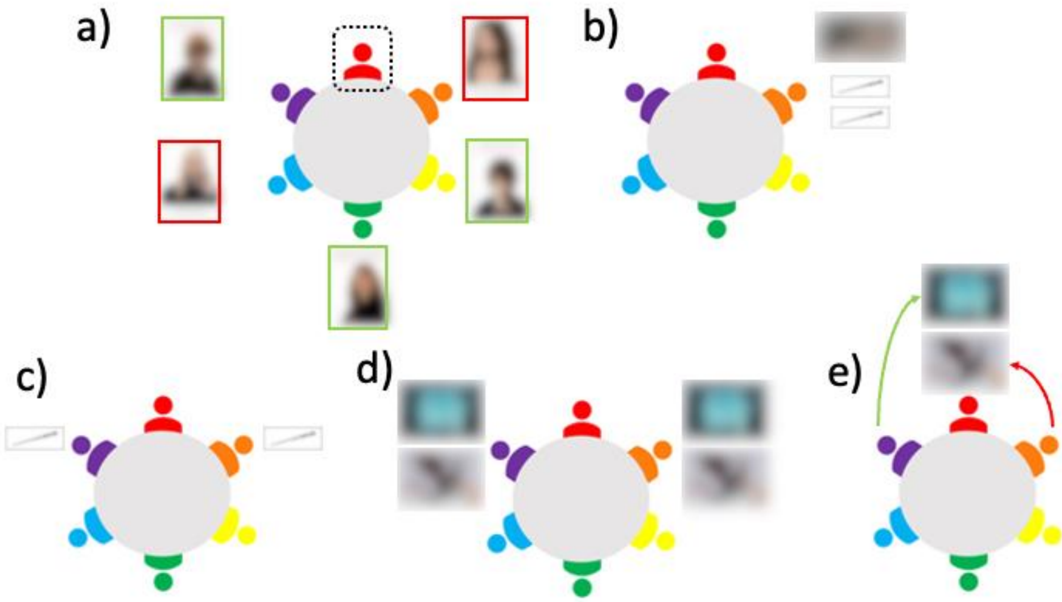

Figure 3-1 Overview of the Hidden Role Game
Note. Images are blurred for copyright purposes.

a) At the start of each game, the experimenter (positioned at the top of the table and depicted as the "red" meeple with the dashed box surrounding her) randomly dealt the player cards to the participants. The orange and the blue players are dealt Death Eater (DE) roles (cards are surrounded in the red for demonstration) and the purple, yellow, and green players are dealt Dumbledore's Army (DA) roles (cards are surrounded in green for demonstration). **b)** Once roles are dealt and the DE members have learned one another's identity, the experimenter assigns the player to her left (orange player) to be the leader of the round. The leader is given the "leader token" and either two or three (based on the current round) wand tokens. **c)** The leader then assigns the wand tokens to any player, including themselves. In this round, the leader (orange players) assigns the wand tokens to themselves and the purple player. **d)** After all participants voted to "accept" or "reject" the team (majority rules), the experimenter deals a "pass card" and a "fail card" to the approved battle team members. In this example, the experimenter deals these cards to the orange and purple players. **e**) The battle team then secretly decides whether to play the "pass card" or the "fail card" by placing the card they wish to play face-down in the play pile and the card they do not wish to play face-down in the discard pile. Because the purple player is a DA member, they must play the "pass card", but the orange player could choose to play either card depending on their goals for the current round. Once both players have placed their cards face-down in their respective piles, the experimenter shuffles the cards before revealing their outcome. In this case, the DE have won the battle and the game will continue until one team has won three rounds.

3.2.2.3 Post-Round Questionnaires

After each of the three games, participants returned to their computers to answer a series of questions about that game. Specifically, participants were asked to indicate their role and to make a forced-choice inference of the role of each of the other players (DE or DA). Participants were also asked several additional questions about their own deception and whether they believed their peers were concealing information during the game. However, these items are not being analyzed within the context of this study (see Appendix D for the full post-round questionnaire). After completing the post-round questions, participants responded to the BFI (John & Srivastava, 1999) and the remaining personality measures.

3.2.2.4 Data Analysis

3.2.2.4.1 Video Processing

Prior to analyzing the video data, I pre-processed the video recordings for offline analysis. The sessions were recorded using three high-definition video cameras, each of which focused on two people (either two participants or one participant and the experimenter). I began by exporting the four sections of the study session (the interaction and the three game rounds) from each recording such that I had four separate video files per camera and per group. To create a set of files for each participant, I edited the films ensuring that they were the only person visible in the frame. The experimenter's videos were not included in analyses. Due to technical errors during data collections, seven participants had no video recordings, and 11 additional participants were missing video recording for one or more game rounds. These participants are still included in analysis because the model I used to estimate the effects allows for and estimates missing data using a Markov Chain Monte Carlo (MCMC) approximation algorithm. Briefly, the MCMC approximation algorithm estimates missing data based on observed data points and the estimated model parameters at each iteration of the model fitting procedure (Hoff, 2015).

I then processed the video data using a frame-differencing method (FDM) coding procedure using custom-written MATLAB code to give an estimate of participants' nonverbal behaviour in each game round (code based on Paxton & Dale, 2013b, available from https://github.com/a-paxton/fdm). The FDM calculates a standardized movement score for each participant using pixel changes on a frame-to-frame basis (Paxton & Dale, 2013b). Because the background for each participant is invariant (i.e., static), pixel change indicates participant movement. I then used these estimates to calculate a participant's average movement for the initial interaction and for each of the three game rounds.

3.2.2.4.2 Social Relations Model with Network Data

To analyze the data, I used a version of the social relations model (SRM), which models round-robin interpersonal ratings to assess for perceiver, target, and dyad effects. The traditional SRM, however, is based on a linear model and assumes a continuous outcome variable and a cross-sectional design (Kenny & Albright, 1987; Kenny et al., 2006; Nestler et al., 2015; Nestler et al., 2017), which does not fit my research design. Instead, I used a repeated measures additive and multiplicative effect (AME) model, which includes the regression terms and covariance structure of the SRM, but accommodates network data with ordinal outcomes (Hoff, 2015; Hoff, 2021; Hoff et al., 2020).

The AME model was specified using a repeated measures ordinal non-symmetric network to predict accuracy across rounds with several nodal (individual) and dyadic characteristics as covariates. Each game round was treated as a time point with the outcome (accuracy) and the covariates entered as repeated measures for each round. Accuracy was coded as -1 (inaccurate) or 1 (accurate) and weighted by participants' own role in the round. Specifically, because DEs had complete knowledge of others' roles, their "guesses" were weighted by a value of 0 and DA-members' guesses were weighted by a value of 1. This weighting scheme makes accuracy an ordinal variable with values of -1, 0, and 1. The effect of this weighting discounts the "guesses" of the DE participants whose knowledge of the other participants' roles was certain.

The nodal covariates in the model included a participant's movement change and role for each round, and their extraversion levels. Movement change was calculated by subtracting a participant's average movement for Round X from their baseline movement, as measured in the 5-minute unscripted interaction. This means that movement change was centered on each individual's baseline such that a value of 0 represents no change, a negative value represents less movement, and a positive value represents more movement. Role was included as a binary variable with DEs coded as 0 and DAs coded as 1. This was used to weight accuracy guesses and to assess whether one role was more "guessable" than the other. Extraversion was operationalized as a participant's score on the extraversion subscale of the Big Five Inventory and did not vary on a round-by-round basis (John & Srivastava, 1999). Like a traditional SRM, the AME model produces regression coefficient estimates for perceiver and target effects for all nodal covariates.

The dyadic covariates in the model were round length and round. Round length was grand-mean centered prior to analysis. Specifically, for each round, I calculated the average round length across all groups and subtracted that value from each group's value. Here, a value of 0 represents the average round length, whereas a negative value represents a round that is shorter than average and a positive value represents a round that is longer than average. Round was included as a dyadic covariate to determine if there is an association between rounds and accuracy ratings.

The AME model, and other network based SRM equivalents, do not allow for multi-network analysis within one model. However, it is appropriate to conduct these network analyses on a network-by-network basis and then subject the resulting coefficients to a meta-analysis (e.g., Daniel et al., 2013; Kisfalusi et al., 2020; Palacios et al., 2022; Snijders & Baerveldt, 2003), which is the strategy this report takes. In this case, I conducted the AME for each group on R using the amen package, which provides Bayesian estimates of the effects (Hoff et al., 2020; see Appendix E for the analysis code). I then conducted a series of meta-analyses in JASP to estimate the overall effects for the data.

3.3 Results

After conducting the AME model for each group, I tested my hypotheses with a series of meta-analyses on JASP using restricted maximum likelihood estimation. To test the hypothesis that increased movement from baseline (see Table 3-1 for round-by-round descriptive statistics) would lead to more accurate judgements from peers, I inputted the estimated target effect for movement as the effect size variable alongside the corresponding standard error (SE) to estimate the overall effect for my sample. I found no evidence to suggest that a target's deviations from baseline movement influenced judgment accuracy, χ^2_{wald}=-1.37, SE=4.20, *p*=.744, 95%CI=[-9.592, 6.854] (Figure 3-2a). Similarly, there was no evidence to suggest that participant's own deviations from baseline movement affected their ability to make accurate judgements as perceivers, χ^2_{wald}=-0.74, SE=4.36, *p*=.865, 95%CI=[-9.293, 7.807] (Figure 3-2b).

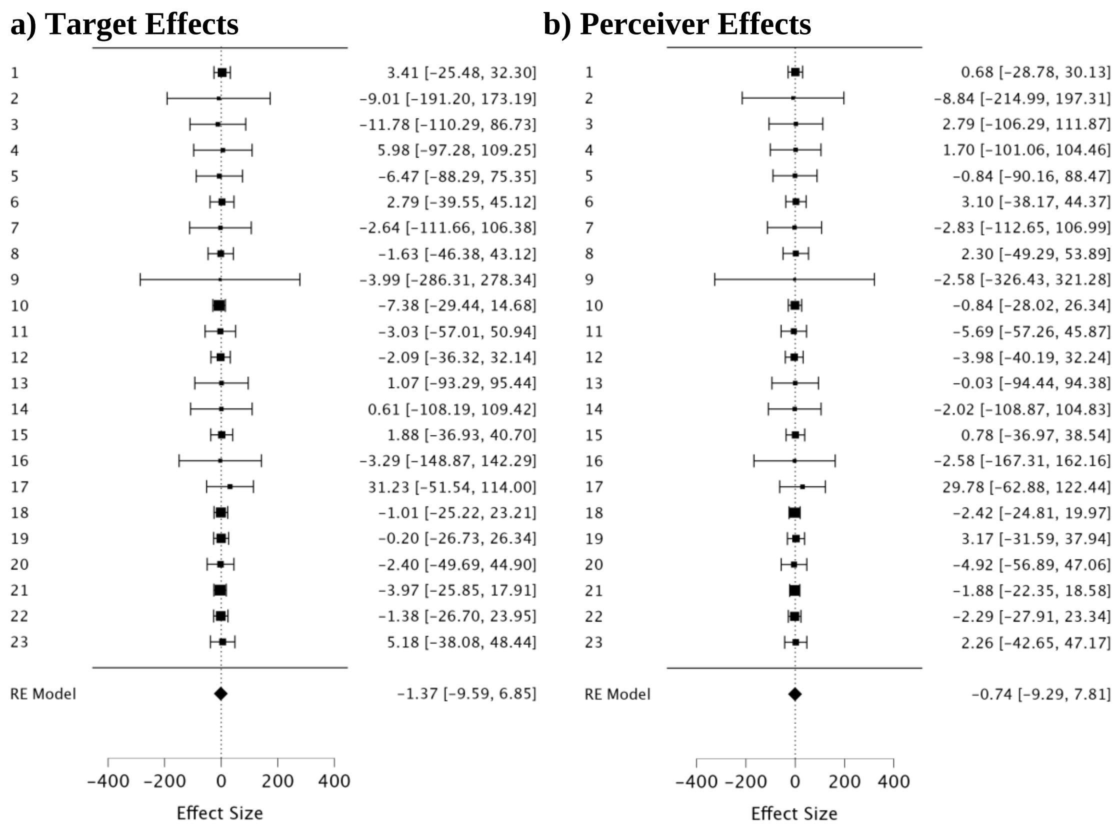

Figure 3-2 Forest Plots for a) Target Effects and b) Perceiver Effects of Movement on Accuracy

For each group (plotted on the y-axis), the effect size and 95% confidence interval from the group SRM model are plotted in the center and provided in text on the right side of the graph. Larger squares represent effects with smaller confidence intervals. The result of the random effects meta-analysis model is presented at the bottom of the forest plot and is represented both pictorially (diamond shape) and in text on the right.

Table 3-1 Descriptive Statistics of Movement (by round), Extraversion, and Round Length in Seconds

	Movement		Extraversion		Round Length in Seconds	
	Average (SD)	Range	Average (SD)	Range	Average (SD)	Range
Interaction	0.0177 (.0126)	0.0035 – 0.0777	4.59 (.7563)	2.63 – 6.25	304.19 (37.09)	218.31 – 354.66
Round 1	0.0225 (.0203)	0.0036 – 0.1051	-	-	624.63 (182.15)	379.32 – 996.93
Round 2	0.0369 (.0368)	0.0036 – 0.1673	-	-	468.61 (171.25)	296.68 – 901.18
Round 3	0.0305 (.0455)	0.0036 – 0.2736	-	-	437.17 (217.41)	176.73 – 923.43

Note. Movement is measured using the FDM procedure and represents participants' average pixel-changes per frame (frame rate of 30 frames per second) for each round. Extraversion was rated on a 7-point Likert scale and is the summary score of the extraversion subscale of the BFI. Round Length is a group variable and is measured in seconds.

I then tested the hypothesis that higher levels of extraversion (see Table 3-1 for descriptive statistics) would lead to more accurate judgements from peers by inputting the estimated target effect for extraversion as the effect size variable alongside the corresponding SE to estimate the overall effect for my sample. The results from this analysis suggested that there was no significant effect of target extraversion on accuracy of judgements, χ^2_{wald}=-0.0003, SE=0.007, p=.969, 95%CI=[-0.014, 0.013] (Figure 3-3a). Similarly, there is no evidence to suggest that a perceiver's extraversion levels influences their judgement accuracy, χ^2_{wald}=-0.12, SE=0.13, *p*=.350, 95%CI=[-0.375, 0.133] (Figure 3-3b).

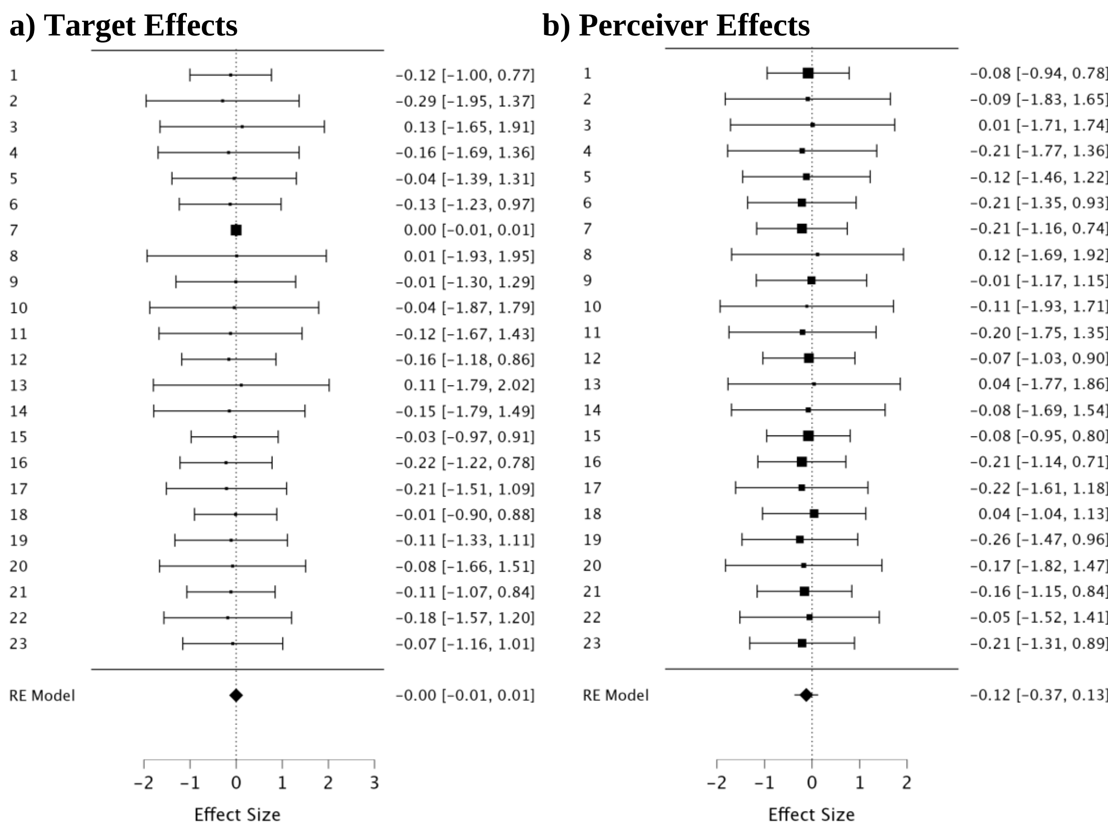

Figure 3-3 Forest Plots for a) Target Effects and b) Perceiver Effects of Extraversion on Accuracy

For each group (plotted on the y-axis), the effect size and 95% confidence interval from the group SRM model are plotted in the center and provided in text on the right side of the graph. Larger squares represent effects with smaller confidence intervals. The result of the random effects meta-analysis model is presented at the bottom of the forest plot and is represented both pictorially (diamond shape) and in text on the right.

Finally, I tested the hypothesis that familiarity with a target would improve one's judgement accuracy. I first assessed whether longer than average round lengths (see Table 3-1 for descriptive statistics) would influence accuracy by inputting the estimated dyadic effect size of round length and the corresponding SE into the meta-analytic model. The results indicated that round length was not associated with accuracy, χ^2_{wald}=-0.00002, SE=.002, *p*=.991, 95%CI=[-0.004, .004] (Figure 3-4a). I then assessed whether accuracy judgements were significantly related to the round in which they occurred by inputting the dyadic effect size of round and the corresponding SE into the meta-analytic model. The results indicated that accuracy was significantly correlated with round, χ^2_{wald}=4.95, SE=0.20, *p*<.001, 95%CI=[4.563, 5.335] (Figure 3-4b).

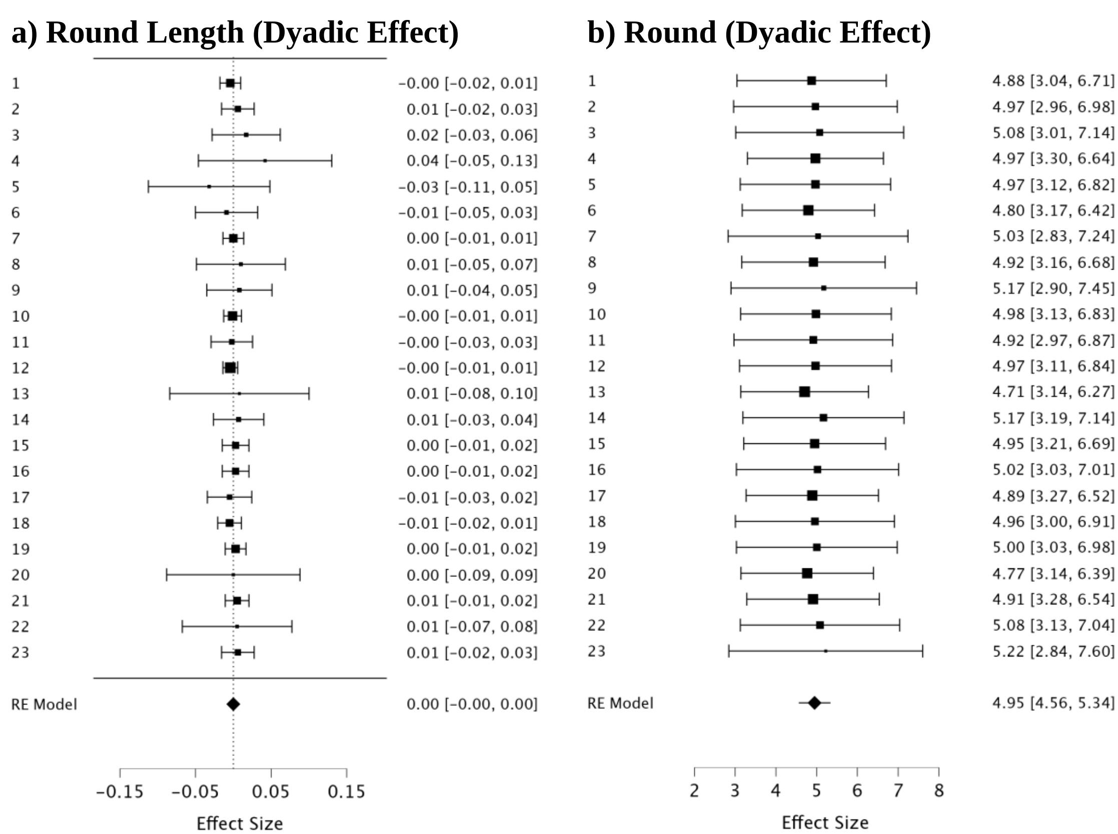

Figure 3-4 Forest Plot for Dyadic Effects of a) Round Length and b) Round

For each group (plotted on the y-axis), the effect size and 95% confidence interval from the group SRM model are plotted in the center and provided in text on the right side of the graph. Larger squares represent effects with smaller confidence intervals. The result of the random effects meta-analysis model is presented at the bottom of the forest plot and is represented both pictorially (diamond shape) and in text on the right.

To determine whether accuracy in Round 3 was greater than Rounds 1 and 2, I conducted one-tailed paired-samples Student t-tests with the group's proportion of correct guesses in each round as the variable pairs. The proportion of correct possible guesses was calculated by dividing the number of correct guesses by DA players by 12 (the total number of guesses by the DA). Due to the small number of groups, I assessed the normality of the distributions using the Shapiro-Wilk test prior to interpretation. In both cases, there was no evidence of a significant deviation from normality, thus I continued with interpretation (Round 3-Round 1: W=0.96, p=.401; Round 3- Round 1: W=0.98, p=.897). Results revealed that compared to Round 1, the proportion of accurate guesses was significantly higher in Round 3, $t(22)$=2.09, p=.024, Cohen's d=.437 (Table 3-1; Figure 3-5a&b). However, while Round 3 does have a higher proportion of accurate guesses compared to Round 2, this was not a significant effect, $t(22)$=1.15, p=.132, Cohen's d=.239 (Table 3-2; Figure 3-5c&d).

Table 3-2 Group Accuracy Ratings per Round

	Round 1	Round 2	Round 3
Correct Guesses (SD)	8.35 (2.21)	8.78 (2.76)	9.78 (2.56)
Proportion Correct (SD)	.696 (0.184)	.732 (.230)	.815(.215)

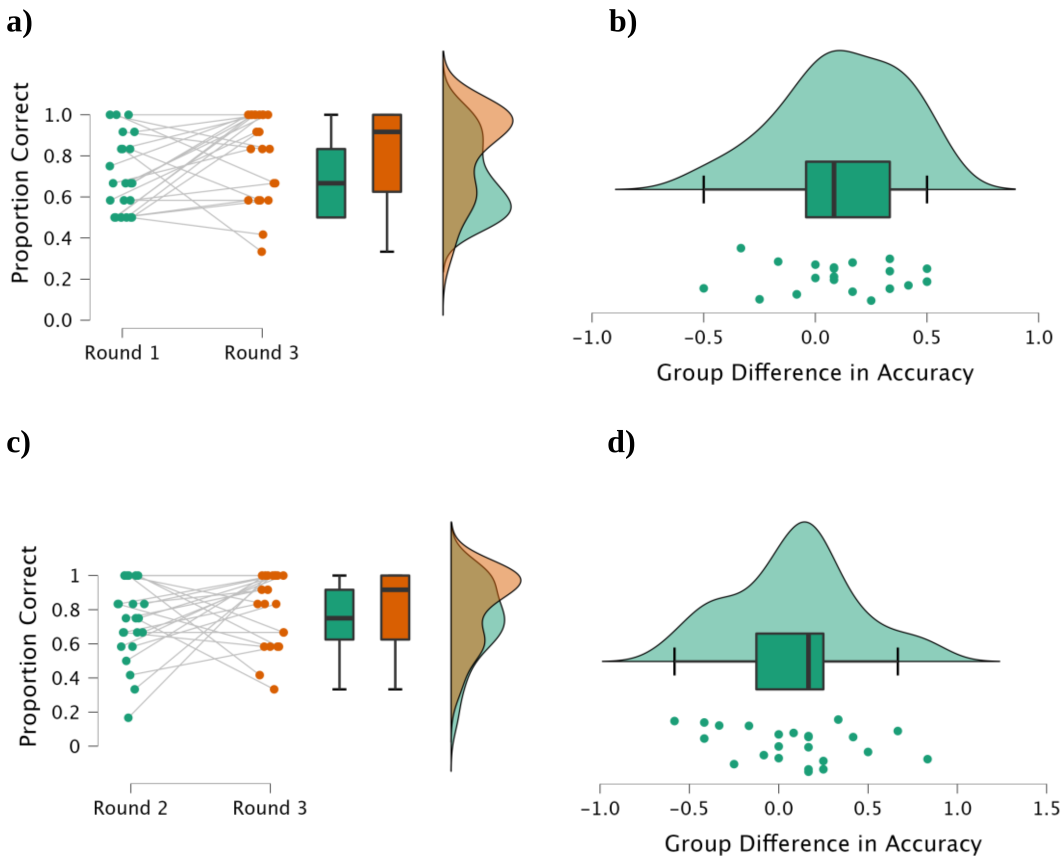

Figure 3-5 Raincloud Plots of Proportion of Accurate Guesses in Round 3 compared to Rounds 1 and 2

Raincloud plots (Allen et al., 2021) show the distribution of data points, a boxplot, and one-sided violin plot. The top panel shows the Raincloud plots for **a)** the paired data in Rounds 1 and 3 and **b)** the difference in a group's proportion of accurate guesses between Rounds 3 and 1. The bottom panel shows the Raincloud plots for **c)** the paired data in Rounds 2 and 3 and **d)** the difference in a group's proportion of accurate guesses between Rounds 3 and 2.

3.3.1 Exploratory Analyses

In addition to testing my hypotheses, I conducted an exploratory analysis to determine if the role a player was assigned (DE or DA) increased the accuracy of their peers' judgements. To do so, I inputted the estimated target effect of role as the effect size variable alongside the corresponding standard error to estimate the overall effect for the sample. The results indicated that there was no significant relationship between the target's role and the accuracy of guesses, χ^2_{wald}= 0.02, SE=.21, *p*=.915, 95%CI=[-0.395, .440] (Figure 3-6).

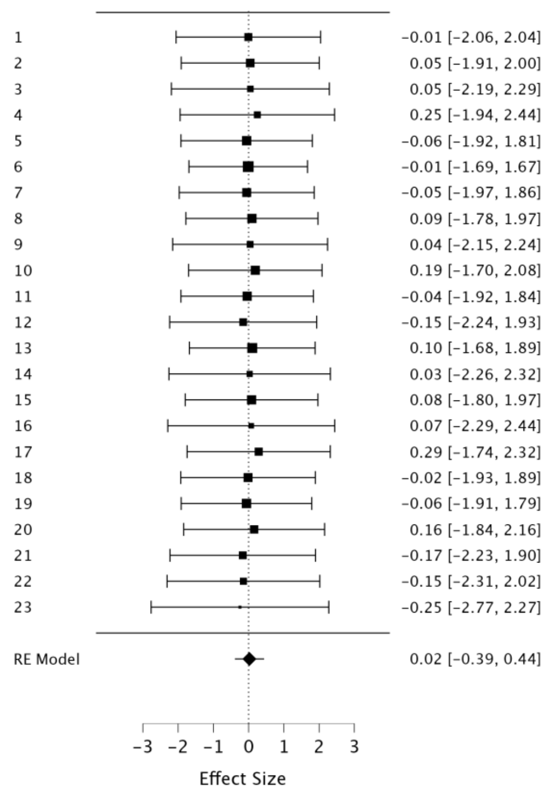

Figure 3-6 Forest Plot of Target Effects of Role on Accuracy

For each group (plotted on the y-axis), the effect size and 95% confidence interval from the group SRM model are plotted in the center and provided in text on the right side of the graph. Larger squares represent effects with smaller confidence intervals. The result of the random effects meta-analysis model is presented at the bottom of the forest plot and is represented both pictorially (diamond shape) and in text on the right.

3.4 Discussion

Contrary to expectations, results from this study show that changes in overall levels of physical movement from baseline movement (e.g., fidgeting, gesturing, posture changes) and extraversion were not related to perceptive or expressive accuracy. Furthermore, I found no evidence to suggest that a target's role was related to their expressive accuracy or that longer than average round lengths increased the accuracy of judgements within a group. However, I did find that the game round in which participants made their judgements was associated with accuracy. Specifically, groups had a higher proportion of accurate guesses in the last round compared to the first round of the game, suggesting that familiarity may be more important than some other types of cues in person perception.

While previous research has reported a significant association between movement and interpersonal accuracy (e.g., Atkinson et al., 2004; Becchio et al., 2012; Manera et al., 2011; Obhi, 2012; Sartori et al., 2011), there was no evidence of such a relationship within this study. One reason why I may have failed to find this effect, is that the research design involved live interactions, whereas the published literature most often relies on video recording of actors' movements. More specifically, my participants interacted with five other people (including the experimenter) throughout the game rounds, making judgements about each of their peers at the end of each round. Other studies, however, have trials consisting of a video of one person's movement followed by a judgement decision before moving on to the next trial (e.g., Sartori et al., 2011). The amount of social information to process prior to making a judgement in my task is substantially greater than that of a trial-based task, which may explain why I did not replicate this effect.

Previous research has also robustly reported that extraversion is a strong predictor of perceptive and expressive accuracy across contexts, partly because it is associated with clearer encoding of social information and better decoding skills (e.g., Hall et al., 2009; Human & Biesanz, 2013; Human et al., 2021; Riggio & Riggio, 2002). This has often been considered advantageous because it supports positive personal and interpersonal outcomes, such as increased social support and decreased loneliness (Human & Biesanz, 2013). There are, however, contexts in which being highly "judgeable" is counter-productive to one's goal, such as in the hidden role game used in this study. Here, it is not strategic to be high in expressive accuracy, and thus participants might have attempted to monitor and minimize their expressiveness to help conceal their role, regardless of extraversion levels. Therefore, the competitive context of the game might have revealed an important boundary condition for this effect. More specifically, despite natural advantages in encoding unambiguous social behaviour, highly extraverted individuals may be able to conceal their intentions and consciously minimize their social behaviour when attempting to be discrete and might have chosen to do so in the context of this game. Therefore, I argue that while extraversion is generally associated with increased perceptive and expressive accuracy, in contexts where it is not advantageous, the effect might be minimized due to an increased effort to control one's behaviour.

Interestingly, the increased effort to control and suppress expressive behaviour may also explain why I did not find evidence to suggest that longer than average round lengths were associated with increased accuracy. This hypothesis was based on the notion that longer interaction times would lead to greater availability of cues from which to make judgements (e.g., Human & Biesanz, 2013). However, if players were actively suppressing the cues that would provide useful information about their role, then I would not expect to find a significant relationship between round length and accuracy. Furthermore, this may also explain why a target's role was not associated with accuracy. Specifically, players who were assigned the DE role might have been attempting to control their "tells", such that perceivers were no more accurate in their judgements of DA compared to DE players. This explanation would be in line with the ample research suggesting that people are indeed able to conceal information and avoid detection with an alarming success rate (e.g., Bond & DePaulo, 2006). Furthermore, much research has reported a "truth bias" in the event of making judgements in uncertain circumstances (e.g., Bond & DePaulo, 2006; Street et al., 2015; Street & Masip, 2015). In this case a "truth bias" might have influenced the DAs perceptive accuracy, leading to an inability to distinguish fellow DA members from DE members.

My results do however lend evidence to support the notion that people make more accurate judgements as they become more familiar with their targets (e.g., Funder & Colvin, 1988, Hofer et al., 2022). Specifically, the finding that accuracy increased with each subsequent game suggests that individuals might indeed update their social inference models over time, leading to a more robust network of prior information in later game rounds (Kilner et al., 2007; Moutoussi et al., 2014b). However, in my study design familiarity with targets is inextricably linked to familiarity with the game, which may also be driving this effect. Because most of my sample had either never played the original version of the hidden role game (72.2%) or were unsure if they had (19.1%), I cannot discount the idea that accuracy in the third round of the game might be higher simply because participants had a better understanding of the rules and thus learned how to make deductions in the context of the game.

One limitation of the current study that hinders my ability to make reliable conclusions from this data, however, is the sample size. Despite the necessity of terminating data collection early to respect the health and safety regulations associated with the COVID-19 pandemic, the unfortunate result is an underpowered study with an increased risk of spurious or inconsequential findings. Nonetheless the unique design of this study provides novel insights into interpersonal accuracy in a naturalistic environment with repeated measures. Although these results should certainly be interpreted cautiously, they provide a foundation for new explorations of the boundaries of interpersonal accuracy in different contexts and demonstrate the importance of including repeated measures designs in this narrative.

Another limitation to this work is that I simplified the naturalistic interaction environment into a movement score to encapsulate expressive social signals on a general level. It might be the case that this does not adequately capture the complexity of social signals and failed to capture the information that people use to make interpersonal judgements. Conversely, I may have failed to find evidence of this effect because the social environment was too complicated to decode this information for each targets simultaneously. As discussed, the social nature of the game was significantly more complicated than the trial-based tasks that have reported this effect in the published literature (e.g., Sartori et al., 2011). Consequently, the additional “noise” in the live interaction may reduce one’s ability to attend to and utilize these cues to make accurate social judgements. Future research should aim to test these ideas with a larger sample to determine if movement is only a reliable indicator of intentions in artificial and unambiguous social environments or if there needs to be a more comprehensive breakdown of social signal processing to understand its impacts on interpersonal accuracy.

Finally, I have speculated that familiarity and repeated exposure to targets is an important aspect of improving interpersonal accuracy because it allows individuals to use predictive social inference with individualized priors. While I did find evidence to suggest that familiarity does indeed lead to more accurate interpersonal judgments, my data cannot speak to the underlying mechanisms driving this relationship. Future research should aim to test these ideas more thoroughly by incorporating repeated measurement designs into the predictive social inference framework. Finally, I have argued that the goals associated with the hidden role game may had caused participants to intentionally suppress their expressive behaviour leading to less skillful decoding by perceivers. This is a reasonable conjecture given that I was unable to replicate robust findings about cue availability and extraversion positively predicting expressive accuracy. However, I cannot test this hypothesis with the current data and urge future research to continue exploring the boundary conditions of these effects.

3.5 Conclusions

Though it is considered advantageous to be high in expressive accuracy, there are situations, such as when trying to conceal information, when individuals may wish to be less expressive. Specifically, I failed to find evidence to suggest that extraversion, a trait commonly associated with more unambiguous social encoding and expressive accuracy, is linked to accurate judgements when targets are instructed to conceal information. This might be because, regardless of extraversion, participants are suppressing expressive behaviours to achieve their goals. These findings demonstrate the importance of considering the social context, and more specifically, the goals of the target when examining expressive and perceptive accuracy. Furthermore, I demonstrate the importance of incorporating repeated measures as my results show that familiarity with a target leads to more accurate judgements over time, suggesting that studies that rely single judgements may not be adequate to investigate the scope of interpersonal accuracy.

Chapter 4

4 Comparing Face-to-Face and Zoom Conversations: The Effects of Non-Verbal Coordination on Conversation Quality and Liking

An important aspect of successful social interactions is the ability to anticipate a social partner's behaviour (Thornton et al., 2019a; Thornton & Tamir, 2021). To do so, people use their partner's actions, states, and traits to predict future behaviour and to respond accordingly (Tamir & Thornton, 2018). In addition to partner behaviour, people also rely on knowledge of established social dynamics and norms for their predictions (Heerey & Crossley, 2013; Koban et al., 2017). For example, conversations that involve a high degree of interpersonal coordination, described as the time-sensitive matching of the same or reciprocal behaviours between interaction partners, are easier to predict, leading to smoother and more fluent interactions (Ackerman & Bargh, 2010; Cappella, 1985; Chartrand & Bargh,1999; Hess, 2020; Genschow et al., 2018; Yabar & Hess, 2007). Conversely, conversations that are characterized by low levels of coordination have been shown to result in negative outcomes for the dyad, such as low levels of affiliation, less liking of the social partner, and lower quality interactions (Arnold & Winkielman, 2020; Heerey & Kring, 2007; Stel & Vonk, 2010).

Most people can skillfully coordinate their social behaviour with an interaction partner, often doing so spontaneously and automatically (Bargh & Chartrand, 1999; Garrod & Pickering, 2004; Hess & Bourgeois, 2010; Kurzius & Borkenau, 2015). Moreover, people show nonverbal interpersonal coordination simultaneously across multiple modalities, including facial expressions (Heerey & Crossley, 2013; Sato & Yoshikawa, 2007), emotions (Hess & Fischer, 2014; Lee, et al., 2006), and head movement and orientation (Bailenson & Yee, 2005; Hale et al., 2020). Conclusions from this work consistently support the notion that greater interpersonal coordination generally predicts positive social outcomes for interlocutors (e.g., Duffy & Chartrand, 2015; Morgan, et al., 2017; Vicaria & Dickens, 2016). Specifically, interactions that involve a great deal of interpersonal coordination are generally considered more enjoyable and fluent than those that are less coordinated (Stel & Vonk, 2010). Likewise, individuals who mimic their interaction partner's behaviour to a high degree are liked more than those who do not mimic their partner (Salazar Kämpf et al., 2017). Thus, interpersonal coordination is often seen as the "social glue" that bonds individuals together (Lakin et al., 2003).

Due to the positive and robust effects associated with interpersonal coordination, researchers have explored innate mechanisms that encourage coordination, such as the mirror neuron system (MNS). Specifically, the MNS is comprised of neurons that activate in a similar pattern when someone watches an action being performed and when they perform the action themselves (Rizzolatti, 2005; Rizzolatti & Craighero, 2004). Researchers have suggested that the MNS facilitates the processing and production of complex social dynamics, such as interpersonal coordination, by linking related behaviours through associative learning and predictive coding (Catmur et al., 2007; Cook et al., 2014; Gallese & Goldman, 1998; Heyes, 2010; Kilner et al., 2007; Koster-Hale & Saxe, 2013; Oberman et al., 2007; Richardson & Saxe, 2019). In social interactions, this system may activate Bayesian-like priors to accurately predict and produce a reciprocal response to a partner, even with minimal information (Griffiths & Tenenbaum, 2006; Hamilton, 2013; Kilner et al., 2007; Wolpert et al., 2003). Indeed, the MNS is an important aspect underlying interpersonal coordination (Chartrand & van Baaren, 2009) and has been shown to be involved in the production of direct imitation (Iacoboni et al., 1999; Likowksi et al., 2012) and complementary responses (Newman-Norlund et al., 2007; Sartori et al., 2013), both of which are characteristics of successful interactions. Evidence additionally points to a role for the MNS in empathic responding (Baird et al., 2011), though not all studies report these relationships (Keysers et al., 2013).

The role of mirror neurons in interpersonal coordination has been cited as theoretical evidence for the presence of a perception-behaviour pathway, which suggests that simply perceiving a behaviour increases the likelihood of reciprocation (Chartrand & Bargh, 1999; Chartrand & van Baaren, 2009; Dijksterhuis & Bargh, 2001). Therefore, conditions that interfere with accurate social perception are likely to influence the degree of interpersonal coordination within an interaction by reducing a person's ability to predict and respond to an interaction partner. For instance, research has shown that when a portion of a target person's face is covered, such as when wearing a medical mask, people are less accurate at judging their facial expressions (Grahlow, et al., 2022; Grundmann, et al., 2022; Langbehn et al., 2022), which can lead to less imitation (Kastendieck et al., 2021). Furthermore, environmental distractions (e.g., noises, cellphone use, other people) can result in gaze aversion and reduced eye-contact, which interfere with one's ability to perceive social cues and respond with a reciprocal behaviour (Vanden Abeele, et al., 2019; Pfeiffer et al., 2012; Wang et al., 2010).

Although disruptions to social perception do occur in face-to-face social contexts, they are arguably more prominent in interactions that occur via video conferencing platforms. For instance, online distractions, such as email, social media, and instant messaging, are simultaneously available during video conferencing, making individuals significantly more distractable and thus more likely to miss important social cues. This has become more concerning since the onset of the COVID-19 pandemic, which necessitated significant changes to how people interact in the workplace, as well as with friends and family. For many people, a large proportion of interactions now occur via video conferencing software (e.g., Zoom, FaceTime, Skype), rather than in the face-to-face context that characterized the pre-pandemic social world. This may have important implications for people's capacity to process social information and coordinate their social behaviour, resulting in negative downstream effects, such as poor interaction quality.

Indeed, there are several unique characteristics of virtual interactions that may act as barriers to social perception and may therefore reduce interpersonal coordination and interaction quality. First, there are unpredictable transmission and timing delays associated with video conferencing software (Boland et al., 2021). This is important because even small delays (~30-100ms) have been shown to decrease interpersonal coordination. For instance, individuals who experience transmissions delays in their conversations spend more time talking over one another and in prolonged silence, which interrupts the flow of the interaction (Boland et al., 2021; Brady, 1971; Egger et al., 2010). Although the impact of the transmission and timing delays associated with video conferencing and phone calls has been well-established with respect to verbal cues, to my knowledge, there has been no investigation on how video conferencing software alters patterns of nonverbal coordination between interaction partners. However, given that the coordination of nonverbal cues is extremely time-sensitive (e.g., Hale et al., 2020), one would expect that such delays would also interfere with one's ability to coordinate nonverbal behaviour with that of an interaction partner.

Another concern regarding the frequent use of videoconferencing is the increased cognitive load associated with sending and receiving cues (Bailenson, 2021; Döring et al., 2022). One reason this might occur is that in calls with multiple conversation partners, people view a grid of different people's videos feeds simultaneously. The close range of the videos and the continuous eye contact from many people on the grid is highly unusual in the face-to-face context and has been associated with lower liking and interaction quality in virtual interactions (Bailenson et al., 2004). Furthermore, cues that are easily interpretable in face-to-face contexts, such as smiles, can be more difficult to decode in a virtual interaction because the cues that people send might be less tightly linked to an interaction partner's behaviour and may instead be the result of something external to the conversation altogether (Bailenson, 2021; Bleakley et al., 2021). The presence of multiple types of external distractions, both on one's own computer (e.g., email, social media) and in the environment, (e.g., partners, pets, or children), can further degrade attentional focus, causing important social information to be missed. Together these factors increase the cognitive load associated with interacting and have been reported to be a cause of "Zoom fatigue" (Bailenson, 2021; Bleakley et al., 2021; Kara & Esroy, 2022).

Another factor that may lead to Zoom fatigue is that many video conferencing platforms allow people to view their own video, in addition to that of their conversation partner(s), which is seldom a feature in face-to-face contexts. This is a default setting on Zoom, meaning that most users see themselves throughout their calls. For regular users, this effectively creates an all-day mirror, which may have negative effects on the individual, such as lower affect and negative self-evaluations (Bailenson, 2021; Fejfar & Hoyle, 2000; Ingram et al., 1988; Potthoff & Schienle, 2021). Indeed, recent research has shown that attending to oneself is a significant predictor of Zoom fatigue, especially among women (Fauville et al., 2021) and those who are conscious of their public image (Kuhn, 2022).

In addition to triggering Zoom fatigue, seeing and attending to oneself during a virtual interaction may cause people to miss the nuance of a partner's nonverbal cues. Specifically, people show preferential attention for their own face (Alzueta et al., 2020; Bola et al., 2020; Bortolon & Raffard, 2018; Wójcik et al., 2018) and have increased difficulty disengaging their attention from their own face compared to other familiar and unfamiliar faces (Devue et al., 2009). Therefore, the self-view feature may be detrimental to the natural flow of conversations because it distracts people from their interaction partner(s), leading to disruptions in social perception. Because accurate social perception is critical to interpersonal coordination (Chartrand & van Baaren, 2009; Dijksterhuis & Bargh, 2001; Likowksi et al., 2012), conversations that occur via videoconferencing platforms, in which distractions are rife, are likely to have lower levels of coordination compared to conversations that occur in the face-to-face context. This disruption to interpersonal coordination is likely to lead to negative consequences for the dyad, such as lower levels of liking for a social partner and reduced interaction quality (Arnold & Winkielman, 2020; Stel & Vonk, 2010). Given the popularity of video conferencing software since the onset of the COVID-19 pandemic, the ongoing disruption to conversational flow may have important consequences for individuals and their relationships.

4.1 Current Research

Although video conferencing has been integral to many people's ability to see co-workers, friends, and family during the COVID-19 pandemic, many of its features may interfere with the natural flow of conversations, likely leading to reductions in interpersonal coordination and to less positive social outcomes. To examine whether and why these occur, I empirically compared 5-minute unscripted dyadic conversations between strangers, recorded in either a face-to-face setting or a video-conference setting. I expected that there would be significantly less nonverbal interpersonal coordination and more self-coordination in virtual conversations compared with face-to-face conversations, leading to reduced reciprocity of social cues. I further anticipated that this would affect social outcomes including subjective interaction quality and liking. In particular, I expected a correlation between interpersonal coordination and interaction quality metrics across both modalities, but because I anticipated less interpersonal coordination in the online interactions on average, I also expected to see lower ratings of interaction fluency.

4.2 Methods

4.2.1 Participants

The data reported in this paper were collected as part of two separate studies that were collected at different time points. The face-to-face dyads were collected prior to the COVID-19 pandemic from December 2019 to February 2020 and the Zoom dyads were collected during the pandemic from February 2021 to March 2021, both in the context of larger studies. Importantly, in both cases, all participants completed the research as part of an introductory psychology participant pool (in exchange for partial course credit), all were assigned to talk to a novel social partner for an unscripted 5-minute interaction, and all completed the interaction at the start of the study, just after the informed consent process and the completion of demographic questionnaires.

I analyzed interaction data from 226 face-to-face participants (paired into 113 dyads) and 286 Zoom participants (paired into 143 dyads). In addition to the partial course credit, the Zoom dyad participants also received a small monetary bonus based on performance in an unrelated task that was part of the larger study. Importantly, this occurred after the interaction and the post-interaction questionnaires. The final sample therefore included a total of 512 undergraduates in 256 dyads (Table 4-1 provides demographic information). All participants gave informed consent and the University’s Ethics Committee approved all study procedures, as well as the secondary use of the data.

Table 4-1. Demographics of Face-to-Face and Zoom Participants

Study	Age	Average Age Differential	Gender	Dyad Composition		
				MM	FF	MF
FtF (N=226)	19.97* (SD=4.25)	2.53 years** (SD=4.19)	F=154(68.1%) M=72(31.9%)	13	54	46
Zoom (N=286)	18.79* (SD=1.51)	1.13 years** (SD=1.80)	F=185(64.7%) M=101(35.3%)	19	61	63
Total (N=512)	19.31 (SD=3.09)	1.74 years (SD=3.17)	F=339(66.2%) M=173(33.8%)	32	115	109

Note. F=female, M=male, MM=two male partners, FF=two female partners, MF=one male and one female partner. *There is a significant difference in age between studies, $F(1,510)=19.01$, $p<.001$. **There is a significant difference in the average age differential between interaction partners between studies, $F(1,254)=13.02$, $p<.001$.

4.2.2 Procedure

4.2.2.1 Face-to-Face Dyads

After providing informed consent, participants first completed a demographic questionnaire. They were then paired with an interaction partner for a 5-minute unscripted interaction. They were seated in chairs approximately 80cm away from one another with video cameras set up 30 centimeters behind each participant's chair at a height of approximately 130 centimeters. Each camera recorded one participant in a forward-facing view. Participants were instructed to get to know one another and told to "talk about whatever you wish" for five minutes. The experimenter left the interaction room for the duration of the interaction.

Immediately after the interaction, the participants returned to their separate testing rooms to complete a post-interaction survey in which they reported their perceptions of interaction quality and how much they liked the partner (Heerey & Crossley, 2013). This questionnaire includes items such as "the interaction was engaging", "the interaction felt natural", "and "I liked my partner", rated on a sliding rating scale. Afterwards, they completed an embedded figures task (de-Wit et al., 2017), along with a series of additional questionnaires (see Patenaude, 2020), which are not part of the present study.

4.2.2.2 Zoom Dyads

After signing up to participate in the study, participants received a link to a Zoom meeting hosted by the experimenter. Once participants joined the call, they completed a consent survey and a short demographic inventory, hosted on Qualtrics (https://qualtrics.com). After this process, they returned to the Zoom meeting for an unscripted 5-minute dyadic interaction. They were given the same instructions as participants in the study that included the face-to-face conversation. The experimenter asked participants to turn on their webcams and microphones for the interaction and recorded the interaction locally on their machine. Experimenters turned off their own camera and microphone and muted the conversation so participants could converse freely.

After the interaction, the experimenter sent each participant an individualized Qualtrics survey link via Zoom's "chat" feature to complete the rest of the study. Once confirming that the participants could access the links, they were instructed to leave the call to complete the remainder of the study. As with the face-to-face dyads, these participants first completed the post-interaction questionnaire with responses measured on a 7-point likert scale with 1 (*Strongly Disagree*) to 7 (*Strongly Agree*) (Heerey & Crossley, 2013). Then, they completed a smile valuation task (for a detailed description, see Heerey & Gilder, 2019; Clerke & Heerey, 2022) and a visual search task in which they located a target face within a set of distractor faces, along with a series of other questionnaires which were not analyzed for the present study but are reported elsewhere (see Heerey et al., 2022).

4.2.3 Data Analysis

Prior to analyzing the data, I inspected the social interaction videos for quality assurance. Here, I focused primarily on the Zoom dyads because I had no control over the webcam quality of individual participants or the environment in which they chose to participate. Specifically, I inspected the videos and adjusted the image size, quality, and brightness, and ensured that both participants' faces were visible throughout the interaction. I then subjected all the social interaction video data to a frame-differencing method (FDM) coding procedure using custom-written MATLAB code to estimate interpersonal and self-coordination (code based on Paxton & Dale, 2013b, available from https://github.com/a-paxton/fdm).

The FDM (Paxton & Dale, 2013b) calculates a standardized movement score for each participant using pixel changes on a frame-to-frame basis. Because the background for each participant is invariant (i.e., static), pixel change indicates participant movement. I then used these estimates to quantify the amount of coordination within the interaction with a series of 48 time-lagged correlation coefficients using a fifteen-frame moving window. For both face-to-face and Zoom dyads, the video recordings for were at 30 frames per second, meaning that this captured the degree to which a behaviour at a particular frame coordinated with behaviours within half-second moving windows, from 12 seconds prior to 12 seconds after the current estimate. These correlations were calculated separately to examine auto-correlation (i.e., how much a person's behaviour coordinates with itself over time) and cross-correlation (how much interaction partners within a dyad coordinate their behaviour with one another over time) across the interaction. From these coefficients, I computed the average autocorrelation (self-coordination) for each individual and the average cross-correlation (interpersonal coordination) across dyad members for the entire interaction.

To assess the impact of the cross and autocorrelations on interaction quality and liking ratings, I inputted these averages into an actor-partner interdependence model (APIM; Kenny & Ledermann, 2010; Kashy & Kenny, 2000; Stas et al., 2018). I opted to use the APIM because it accounts for the interdependence of observations in dyadic data by estimating both an actor and a partner effect. In other words, it accounts for the effect of each individual's predictor variable score on their own rating (actor effect), as well as their predictor variable score on their partner's rating (partner effect). To conduct this analysis, I used the structural equation modelling feature in JASP with code adapted from a Shiny web app that estimates model fit using SEM (see Appendices F & G for the JASP code; Stas et al., 2018).

4.3 Results

Prior to testing my hypotheses, I compared the average liking and interaction quality ratings in Zoom and face-to-face dyads with a two one-way ANOVAs. Here, interaction modality was the independent variable and liking and interaction quality ratings were the dependent variables. Importantly, liking and interaction quality ratings were converted to a proportion ranging from .00 to 1.00 so that they could be compared across interaction modalities. Results from these analyses show that face-to-face dyads had a higher degree of liking between partners (F(1,510)=17.04, p<.001, η_p^2=.032) and higher quality interactions (F(1,510)=28.13, p<.001, η_p^2=.052) compared to Zoom Dyads (Table 4-2).

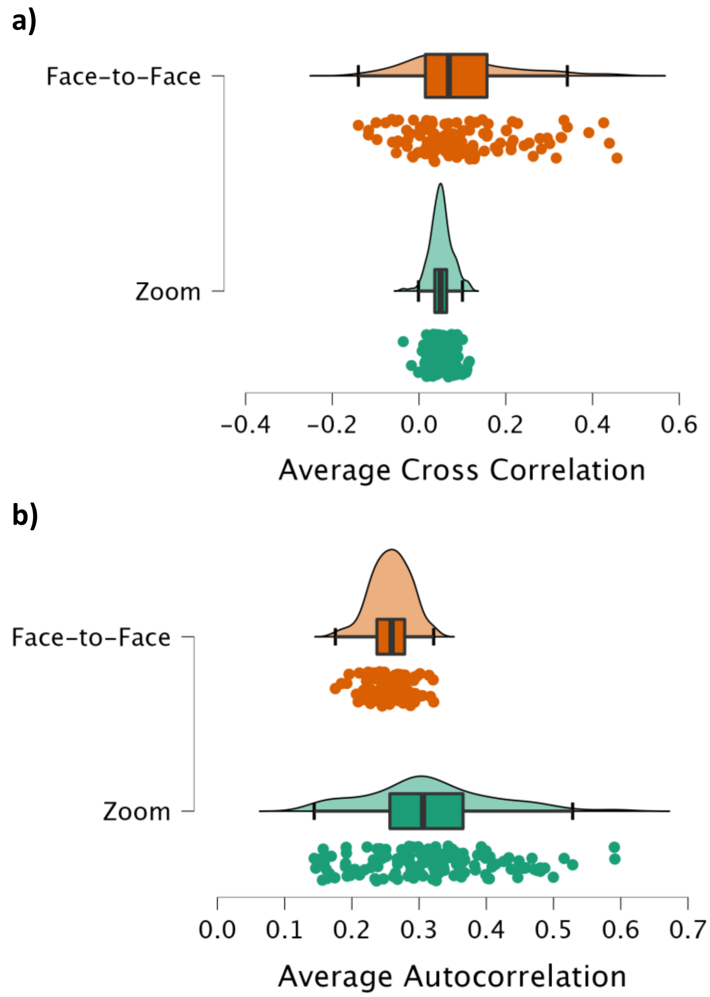

Figure 4-1 a) Average Cross and b) Autocorrelations in Face-to-Face and Zoom Dyads

Raincloud plots (Allen et al., 2021) show the distribution of data points, a boxplot, and one-sided violin plot for Face-to-Face and Zoom dyads for a) the average cross correlation between dyed members and b) the average autocorrelation across dyad members

Table 4-2 Average Liking and Interaction Quality Ratings by Interaction Modality

Interaction Modality	Average Liking Rating	Average Interaction Quality Rating
Face-to-Face (N=226)	.852 (SD=.134)	.809 (SD=.143)
Zoom (N=286)	.798 (SD=.155)	.746 (SD=.125)

To test the hypothesis that there would be significantly less nonverbal interpersonal coordination in the virtual conversation compared to the face-to-face conversations, I conducted a one-way ANOVA with interaction modality (Zoom vs. face-to-face) as a fixed-factor and the average cross-correlation between interaction partner's behaviour as the dependent variable (see Table 4-3 for descriptive statistics). As expected, there was significantly less interpersonal coordination in the Zoom dyads compared to the face-to-face dyads, $F(1,254)=16.46$, $p<.001$, $\eta_p^2=0.06$ (Figure 4-1a). I conducted a similar analysis with the average autocorrelation as the dependent variable to test the hypothesis that there would be significantly more self-coordination in the Zoom conversations (see Table 4-3 for descriptive statistics). As expected, there was significantly more autocorrelation in the Zoom compared to the face-to-face conversations, $F(1,254)=40.01$, $p<.001$, $\eta_p^2=0.14$ (Figure 4-1b).

Table 4-3 Average Autocorrelation and Cross Correlations for Face-to-Face and Zoom Dyads

Interaction Modality	Average Autocorrelation	Average Cross Correlation
Face-to-Face	.258 (SD=0.029)	.094 (SD=0.126)
Zoom	.316 (SD=0.094)	.051 (SD=0.025)

4.3.1 Liking APIM

I then conducted APIM analyses treating the dyads as indistinguishable to test whether differences in interpersonal coordination (i.e., cross correlation) and self-coordination (i.e., autocorrelation) correlated with ratings of how much individuals liked their interaction partner in both the face-to-face and Zoom dyads. For each group, both partners' average autocorrelation was included in the model as the predictor variables and each partner's rating of how much they liked their partner was included as the dependent variables. The average cross correlation between partners was included as a continuous between-dyad covariate. All variables were standardized prior to estimation. The models were estimated using full information maximum likelihood estimation with robust standard error calculations. Both the face-to-face ($\chi^2(8)=3.37$, $p=.909$; RMSEA=0.00, 95%CI[0.000,0.044]; CFI=1.00; TLI=1.12; SRMR=0.04) and Zoom ($\chi^2(8)=9.98$, $p=.266$; RMSEA=0.04, 95%CI=[0.000, 0.112]; CFI=0.97; TLI=0.96; SRMR=0.06) models show good model fit.

Table 4-4 APIM Estimates for Liking for Face-to-Face and Zoom Dyads

Interaction Modality	Effect	Estimate	SE	z-value	95% CI	p-value
Face-to-Face	Actor	-0.046	.066	-0.694	-0.175, 0.083	.487
	Partner	-0.137	.052	-2.657	-0.239, -0.036	.008
Zoom	Actor	0.060	.059	1.01	-0.056, 0.176	.312
	Partner	-0.217	.063	-3.457	-0.340, -0.094	<.001

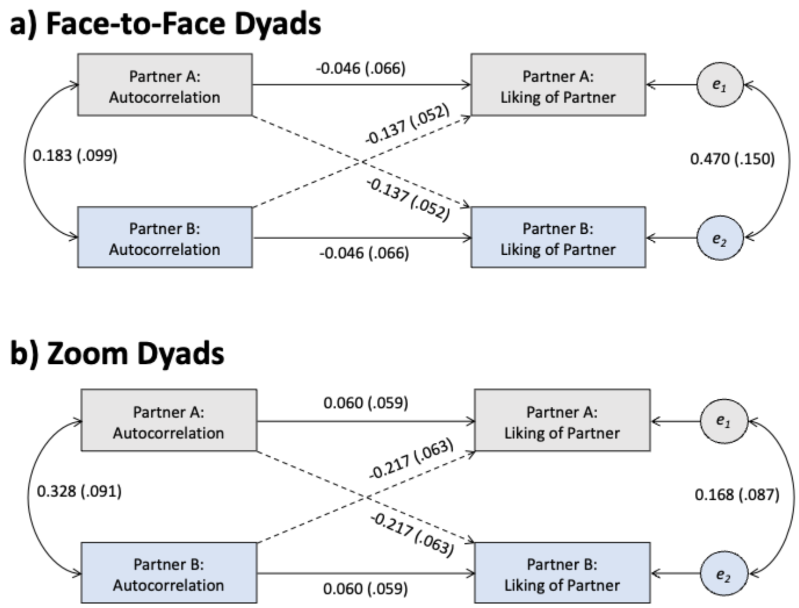

Figure 4-2 Liking APIM Results for a) Face-to-Face and b) Zoom Dyads
APIM estimates for indistinguishable dyads. Standardized path coefficients are reported with standard errors in parentheses. Solid lines indicate actor effects and dashed lines represent partner effects. Lines with single arrows represent predictive paths and curved double-headed arrows represent correlations. For simplicity of interpretation the covariate is not displayed but is reported in the main text.

The actor effect for autocorrelation, or the relation between Partner A's autocorrelation and Partner A's liking rating for their partner/Partner B's autocorrelation and Partner B's liking rating for their partner, was not significant for the face-to-face or Zoom dyads (Table 4-4; Figure 4-2). However, the partner effect for autocorrelation, or the relation between Partner A's autocorrelation and Partner B's liking for A/Partner B's autocorrelation and Partner A's liking for B, was significant in both the Face-to-Face and Zoom Dyads (Table 4-4; Figure 4-2). This suggests that the degree to which autocorrelation is present in an interaction significantly impacts how much they are liked by their interaction partner, such that increases in autocorrelation were associated with decreased liking. Specifically, for face-to-face dyads, each unit increase in autocorrelation was associated with a .137 decrease in how much individuals were liked by their partner. Furthermore, for Zoom dyads, each unit increase in autocorrelation was associated with a .217 decrease in how much individuals were liked by their partner. To compare the magnitude of this effect between face-to-face and Zoom dyads, I conducted a simple slopes analysis (Robinson et al., 2013), which revealed that the partner effect of autocorrelation on liking was not significantly different between interaction modalities, $t(252)=0.98$, $p=.328$.

I also assessed the effect of the average cross-correlation between dyads as a covariate within these models. For both interaction modalities, the average cross correlation significantly predicted how much Partner A liked Partner B (face-to-face: $\beta=0.23$, $p=.021$, 95%CI=[0.034, 0.416]; Zoom: $\beta=0.28$, $p=.003$, 95%CI=[0.095, 0.464]). A simple slopes analysis revealed that this effect is not significantly different between interaction modalities, $t(252)=0.56$, $p=.576$. Likewise, the average cross-correlation significantly predicted how much Partner B liked partner A in both face-to-face dyads ($\beta=.23$, $p=.045$, 95%CI=[0.005, 0.457]) and Zoom dyads ($\beta=.32$, $p<.001$, 95%CI=[0.136, 0.502]). However, as above, this effect does not differ significantly between face-to-face and Zoom dyads, $t(252)=0.56$, $p=.552$.

4.3.2 Interaction Quality APIM

Similarly, I conducted APIM analyses with indistinguishable dyads to test whether differences in interpersonal coordination (i.e., cross correlation) and self-coordination (i.e., autocorrelation) related to ratings of interaction quality in both the face-to-face and Zoom dyads. Each partner’s average autocorrelation was included in the model as the predictor variables and each partners’ rating of the interaction quality was included in the model as the dependent variable. As with the liking APIM, the average cross correlation between partners was included as a continuous between-dyads covariate. All variables were standardized prior to estimation. The models were estimated using full information maximum likelihood estimation with robust standard error calculations. Both the face-to-face ($\chi^2(8)=13.46$, $p=.097$; RMSEA=0.078, 95%CI=[0.000,0.148]; CFI=0.879; TLI=0.848; SRMR=0.063) and Zoom models ($\chi^2(8)=5.84$, $p=.666$; RMSEA=0.000, 95%CI=[0.000,0.079],CFI=1.000; TLI=1.058; SMRM=0.839) show acceptable model fit.

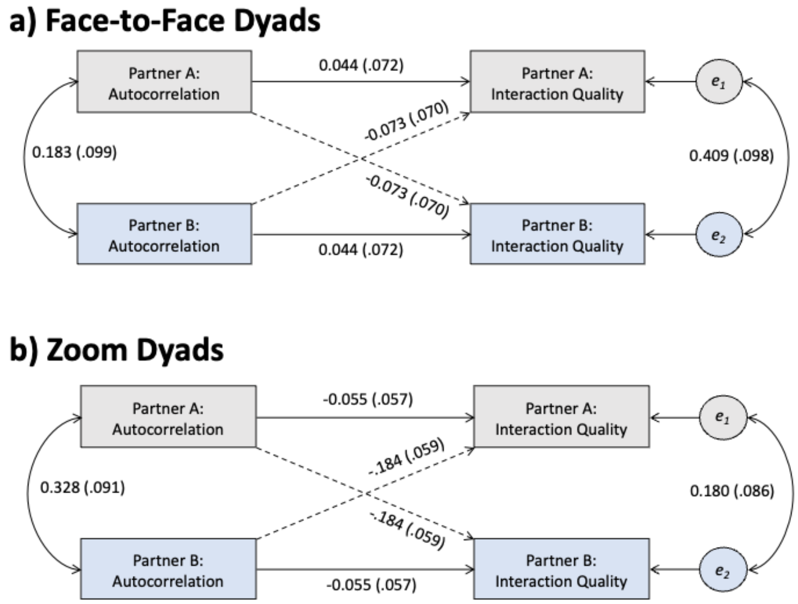

Figure 4-3 Interaction Quality APIM Results for a) Face-to-Face and b) Zoom Dyads

APIM estimates for indistinguishable dyads. Standardized path coefficients are reported with standard errors in parentheses. Solid lines indicate actor effects and dashed lines represent partner effects. Lines with single arrows represent predictive paths and curved double-headed arrows represent correlations. For simplicity of interpretation the covariate is not displayed but is reported in the main text.

The actor effect for both the face-to-face and Zoom dyads was not significant, suggesting that individuals' level of autocorrelation did not impact their own rating of interaction quality (Table 4-5; Figure 4-3). The partner effect for the face-to-face dyads was also not significant, suggesting that an individuals' autocorrelation did not impact their partner's rating of the interaction quality (Table 4-5; Figure 4-3a). Interestingly, however, the partner effect for the Zoom dyads was significant, suggesting that the degree to which autocorrelation was present significantly affected how social partners rated the quality of the interaction. Specifically, for individuals who interacted on Zoom, for each unit increase in the degree of autocorrelation, partner-rated interaction quality decreased by .184. To test whether the magnitude of the partner effect was influenced by the interaction modality, I conducted a simples slopes analysis, which revealed that the slopes were not significantly different from one another, $t(252)=1.21$, $p=.226$.

Table 4-5 APIM Estimates for Interaction Quality for Face-to-Face and Zoom Dyads

Interaction Modality	Effect	Estimate	SE	z-value	95% CI	p-value
Face-to-Face	Actor	0.044	.072	0.614	-0.098, 0.187	.539
	Partner	-0.073	.070	-1.037	-0.210, 0.065	.300
Zoom	Actor	-0.055	0.057	-0.963	-0.168, 0.057	.336
	Partner	-0.184	0.059	-3.102	-0.301, -0.068	.002

As with the liking APIM, I assessed the effect of the average cross-correlation between dyads as a covariate within these models. For both interaction modalities, the average cross correlation significantly predicted how highly Partner A rated the interaction quality (face-to-face: β=0.24, *p*=.009, 95%CI=[0.061, 0.421]; Zoom: β=0.25, *p*=.004, 95%CI=[0.081, 0.419]). I then conducted a simple slopes analysis on these estimates, which revealed that the magnitude of the effect was not significantly different between modalities, *t*(252)=0.07, *p*=.943. For those who interacted on Zoom, the average cross-correlation significantly predicted how highly Partner B rated the interaction quality (β=0.26, *p*=.003, 95%CI=[0.092, 0.435]), however, this relationship was not significant for those who interacted face-to-face (β=0.22, *p*=.068, 95%CI=[-0.016, 0.454]).As above, this effect does not differ significantly between face-to-face and Zoom dyads, *t*(252)=0.30, *p*=.767.

4.4 Discussion

Results from this study suggests that, as expected, interactions that occur in the face-to-face context have significantly more interpersonal coordination (i.e., cross correlation) than those that occur on Zoom. Across both interaction modalities, the average level of interpersonal coordination between dyad members significantly predicted liking of an interaction partner. Furthermore, in face-to-face interactions, interpersonal coordination between dyad members predicted interaction quality ratings. However, for those who interacted on Zoom, this relationship was only significant for Partner A's (arbitrarily assigned) rating of interaction quality. This suggests that while overall, greater degrees of interpersonal coordination are associated with better interaction outcomes, the relationship between interpersonal coordination and interaction quality may not be as robust for virtual interactions.

I additionally found support for the hypothesis that there would be significantly more self-coordination (i.e., autocorrelation) in the Zoom compared to face-to-face dyads. Indeed, high degrees of autocorrelation negatively impacted interaction outcomes, regardless of interaction modality. The APIM results demonstrate that across both interaction modalities the degree to which autocorrelation was present in one partner's behaviour significantly predicted how much that individual was liked by the interaction partner. Specifically, the more autocorrelation present in a participant's social behaviour, the less they were liked by their interaction partner. Interaction quality, however, was only impacted by the degree of autocorrelation for those who interacted on Zoom and not those who interacted face-to-face. Specifically, as the amount of autocorrelation increased, interaction quality, as rated by the partner, decreased. This suggests that the negative impacts of autocorrelation on interaction outcomes may be more robust in virtual interactions compared to more traditional conversation modalities.

These findings, though interesting, are not without limitations. First, this investigation was quasi-experimental and used pre-existing video data from two different studies to compare virtual and face-to-face interactions. Although the data collection procedures up to the social interaction were similar, the protocols were finalized, and data collected prior to the onset of this research project. This meant that additional measures could not be added prior to data collection to enrich the comparisons between the two interaction modalities. Furthermore, the face-to-face dyads were collected prior to the COVID-19 pandemic, whereas the Zoom dyads were collected during the pandemic when lockdown protocols in Ontario were in full effect. The differences we found between interaction modalities could indeed be caused by the changes that resulted from the pandemic, particularly increased concerns surrounding mental health. It may then be the case that increases in anxiety and depression that were thought to characterize periods of lockdown in the pandemic could have changed the ways people were able to coordinate their behaviour as well as interaction fluency measures. However, using pre-existing data helped mitigate the challenges associated with collecting dyadic interactions, such as arduous participant recruitment and limited access to pooled lab space and equipment. In addition, this method circumvented the COVID-19 safety protocols for in-person data collection because the face-to-face dyads were collected prior to the onset of the pandemic. Additionally, using existing recordings allowed for a larger sample size and greater statistical power than would have been possible had I collected new data. Together, the benefits of using existing data outweighed the advantages of collecting a new dataset where interaction modality could be randomly assigned to participants, although this should be an important element of future research investigating these questions.

Second, I coded behavioural coordination using a simplified movement metric. The FDM codes for overall movement, and specifically in this case any movement above shoulder level – which was all that the present video recording protocols captured (Paxton & Dale, 2013b). However, there are more precise measures of interpersonal coordination that focus on specific regions of the body (e.g., head movement and orientation; Bailenson &Yee, 2005; Hale et al., 2020), facial expressions (e.g., Heerey et al., 2022; Heerey & Crossley, 2013; Sato & Yoshikawa, 2007), and emotions (e.g., Hess & Fischer, 2014; Lee et al., 2006). These detailed metrics may enhance this narrative by giving a more nuanced understanding of how nonverbal coordination differs between virtual and face-to-face interactions and the resulting impact on interaction outcomes. However, quantifying and analyzing more nuanced measures of coordination is often a time-consuming endeavor that requires specific data collection setups, thorough manual coding, and expensive equipment (e.g., Bernieri et al., 1994; Drimalla et al., 2019; Kyranides et al., 2022). A benefit of FDM over more specialized techniques is that it allows for a more Gestalt understanding of how individuals coordinate their behaviour without requiring a specialized recording equipment and analysis techniques (Paxton & Dale, 2013b). Importantly, automated coding techniques, such as FDM, have been shown to be appropriate for quantifying coordination between interlocutors and are positively correlated with more arduous hand coding procedures (Fujiwara et al., 2020). Moreover, because understanding the differences in nonverbal coordination in face-to-face and virtual conversations is relatively novel, this approach was an appropriate first step. It also remains to be seen whether behavioural coordination differences would be found if the dyad members were friends, rather than strangers as in this study.

Finally, I have suggested that interpersonal coordination might be impaired in virtual interactions because the environment is more distracting compared to more traditional face-to-face interactions, but I cannot test this theory with my sample. I do however provide evidence to suggest that interpersonal coordination is indeed impaired in virtual interactions and that a higher degree of interpersonal coordination is positively related to both increased liking of an interaction partner (regardless of modality) and higher ratings of interaction quality. This suggests that reductions in interpersonal coordination associated with virtual interactions are indeed likely to produce poorer interaction outcomes. Future research could investigate whether distractions associated with virtual interactions are causing reduced interpersonal coordination by manipulating the presence of distractions in both modalities. To test these ideas, researchers could employ eye-tracking software to assess joint attention (Pfeiffer et al., 2012) and to understand whether these distractions are leading individuals to miss critical social cues from their partners, thereby reducing interpersonal coordination and worsening interaction outcomes.

4.5 Conclusions

These findings indicate that dyad members coordinate their behaviour to a lesser degree in virtual compared to face-to-face interactions, and instead show a higher degree of self-coordination (i.e., autocorrelation). Furthermore, I found that interpersonal coordination is positively associated with interaction outcomes, suggesting that virtual conversations may reduce liking and interaction quality. In particular, the presence of high levels of autocorrelation leads to lower levels of liking of an interaction partner in both modalities, and lower interaction quality, particularly for Zoom conversations. These findings lend support to the notion that virtual interactions interfere with the natural flow of conversations (Boland et al., 2021) and extend this disruption to nonverbal coordination. Although I did not test this specifically, the reduction in interactional fluency associated with virtual conversations might partially explain why virtual conversations feel more effortful (e.g., as in the phenomenon of Zoom Fatigue) and less enjoyable compared to those that occur in the face-to-face context.

Chapter 5

5 General Discussion

The work presented here assesses how the value of nonverbal social cues along with their interpersonal-perception-related and affiliative functions change because of the social context and environment. Specifically, Chapter 2 tested whether thinking about a recent social media post or synchronous conversation altered people's responses to social and monetary rewards. Here, we found that people who were thinking about a recent social media post, but not a synchronous conversation were more likely to forego monetary gains for the chance to see a genuine smile. This suggests that social media interactions might change the subjective utility and desire for social rewards and connection.

Chapter 3 tested how nonverbal social signals impact interpersonal accuracy in a repeated measures hidden role game. Here, I found no evidence to suggest that general movement (e.g., fidgeting), extraversion, or the amount of time spent conversing predicted perceiver or target accuracy. However, the results demonstrated that predictions became more accurate with each round, suggesting that familiarity is an important factor in making interpersonal judgements. Specifically, in addition to learning general social rules, individuals might learn to associate behaviours and outcomes idiosyncratically.

Chapter 4 tested whether interacting via video conferencing platforms, such as Zoom, interfered with people's ability to coordinate their behaviour with an interaction partner and whether this impacted interaction outcomes. Here, I found that interactions that occurred on Zoom, compared to face-to-face, had lower levels of interpersonal coordination, resulting in less liking and lower ratings of interaction quality. Furthermore, Zoom dyads had higher levels of autocorrelation (i.e., self-coordination) compared to face-to-face dyads, and regardless of modality, that higher degrees of autocorrelation led to less liking of an interaction partner. Finally, Zoom dyads demonstrated lower interaction quality ratings associated with increased levels of autocorrelation.

5.1 Implications

These findings highlight the social nature of nonverbal behaviour. Indeed, the overarching theme of this work is that the social environment in which interactions occur affects the way people process and respond to social cues and behaviour. This suggests that the social environment is *integral* to nonverbal behaviour and should be a key aspect of research designs investigating research questions related to social behaviour. As such, this work addresses an important gap in the research literature. Specifically, much of the work on nonverbal social cue exchange has prioritized internal validity and experimental control over external validity and generalization (e.g., Chartrand & Bargh, 1999; Clerke & Heerey, 2021; Dimberg, 1982; Ekman et al., 1969; Ekman & Friesen, 1971; Hess & Blairy, 2011). While this is useful and important work, it might lead to findings that are not supported in naturalistic environments. For example, the results presented in Chapter 3 did not support robust predictors of interpersonal accuracy (e.g., movement, extraversion; Ambady & Rosenthal, 1998; Atkinson et al., 2004; Becchio et al., 2012; Gross & John, 2003; Human et al., 2021; Manera et al., 2011; Obhi, 2012; Riggio & Riggio, 2002; Sartori et al., 2011). This might be the case because these findings stemmed from predominantly social-context-free methodologies. For example, in some of these studies, participants were shown video recordings of an arm and asked to make predictions about the person's intentions, thus reducing the amount of social information normally present in an interaction (Becchio et al., 2012). Here, participants' attention may have been unnaturally focused on the arm, allowing them to make accurate predictions based on information they might normally miss in a naturalistic interaction. In contrast to much of the published literature, the study presented in Chapter 3 used a highly complex social situation with many interaction partners. Because experimenters did not direct participants' attention in any specific way, they may have allocated their attention to the social environment in a more naturalistic manner, thereby missing cues present in the experimental context. Another possibility is that these findings might extend to naturalistic social interactions with fewer partners, but not in a group context.

This set of findings also suggests that the goals associated with an interaction might influence the ways in which nonverbal behaviour is displayed and understood. For instance, the game used in Chapter 3 represents a competitive context in which the goal is to garner information about others while concealing information about one's own role. In this context, I failed to find evidence to suggest that extraversion was related to perceptive or expressive accuracy. This may be because encoding accurate and relevant cues was inconsistent with participants' goals in the game. Indeed, skillful encoding and decoding is often thought to be a social advantage of extraverted individuals because it fosters better communication and understanding between interaction partners (Human & Biesanz, 2013; Riggio & Riggio, 2002). However, this does not mean that highly extraverted individuals are unable to control their expressiveness (e.g., Bond & DePaulo, 2006). Indeed, they may have chosen to do so here to align their behaviour with their goals within the game. This suggests that researchers need to consider broader contextual factors, such as interaction goals, to understand the boundary conditions of even well-established effects.

Moreover, these findings indicate the importance of familiarity in the precision of social predictions and interpersonal accuracy. In Chapter 3, I reported that judgement accuracy increased as a function of familiarity with one's social partner. Specifically, with each successive game round, participants made more accurate judgements about the other players in the game, suggesting that they become more attuned to their idiosyncratic behaviours. However, much of the research in this domain has focused on stranger interactions in one-shot decision-making paradigms (e.g., Latif et al., 2021; Olivola & Todorov, 2009; Vrji, 2016). This may not fully capture the social nature of interpersonal accuracy and how it changes over time. To add nuance to the understanding of social predictions and interpersonal accuracy in the naturalistic environment, researchers should consider incorporating cross-sectional repeated measures, as presented here, or longitudinal designs (e.g., following newly acquainted friends or romantic partners over time as in some previous research; Stanton et al., 2017; Gottman & Levenson, 2004; Houser et al., 2008).

Findings from Chapters 2 and 4 highlight that the modality in which a conversation occurs has important implications for both the subjective value of social rewards and the ability for interaction partners to coordinate their behaviour. Specifically, the finding that the subjective value of social rewards is increased when people are thinking of a recent social media post, but not a synchronous conversation, indicates that social media interactions may not fulfill social connection to the same degree as traditional conversations and that these unfulfilled affiliation needs might increase the incentive value of social rewards. Furthermore, interpersonal coordination and its associated positive interaction outcomes are contingent on the modality of the social interaction. Specifically, conversations that occur on Zoom had lower levels of interpersonal coordination, and higher levels of self-coordination, compared to those that occurred face-to-face. Importantly, the difference between interaction modality was linked to lower levels of liking and interaction quality, suggesting that social outcomes differed as a result how individuals engage with their social partners. Indeed, computer-mediated communication (e.g., text messages, instant messaging, emails), phone calls, and video calls can disrupt the natural flow of interactions even when they are not constrained or manipulated by experimenters (e.g., Boland et al., 2021; Brady, 1971; Egger et al., 2010; Vanden Abeele et al., 2019). Thus, exploring social behaviour in different contexts is important for understanding the scope of how nonverbal cue presentation and interpretation changes because of the diverse communication technologies used in modern life.

Together, these findings suggest that in addition to the general social environment, the modality of the social exchange and individuals' goals within interactions are also important factors to consider because they may change the ways people signal and value social cues. This may then subsequently change the ways in which people are able to predict and coordinate their behaviour with a social partner, which has been demonstrated to have negative downstream outcomes for interaction partners and social relationships. Understanding these contingencies with greater precision through continued exploration of diverse social contexts will help determine boundary conditions for established effects, thus strengthening our command of the functionality of nonverbal cue exchange and behaviour in the social sphere.

5.2 Limitations

Beyond the specific limitations discussed in each empirical chapter, there are two general limitations that I must highlight. Throughout this dissertation, I've argued that including naturalistic interactions in nonverbal communication research is paramount. I have done this in the studies presented in Chapters 3 and 4, which is the primary strength and contribution of this work. However, this high external validity comes at the cost of experimental control. This means that I cannot make strong causal inferences from this work due to the unconstrained and undirected behaviours that are inherent to naturalistic social interactions. Although most interactions followed the same general topics that one might expect from undergraduate students who are meeting for the first time (e.g., year of study, majors, residence halls, hobbies/interests), we cannot make conclusions about whether these conversations were drastically different from one another simply because of group dynamics and interaction modality or if there are other reasons underpinning our findings. Thus, optimally there would be a balance in this field between experiments with high internal validity (i.e., methodology using highly constrained social stimuli) and studies with high external validity (i.e., investigations of unconstrained natural social behaviour). However, the field is currently biased towards highly constrained experiments, thus the investigations presented here contribute towards balancing this scale.

Second, the metrics I used to assess nonverbal behaviour and coordination were not focused or precise. For instance, much of the theoretical background presented focused on facial displays and their communicative value (e.g., Crivelli & Fridlund, 2018; Feldman Barrett et al., 2011; Feldman Barrett et al., 2019; Hess & Hareli, 2017). While cues stemming from body language and movement are also considered valuable for social predictions (Cristani et al., 2013; Hagad et al., 2011; Hale et al., 2020; Heerey & Kring, 2007), research has demonstrated that, in general, people are more attentive to facial displays (e.g., Schindler & Bublatzky, 2020). For this reason, I originally planned to include more precise metrics, such as facial displays captured by action units, in the results presented in Chapter 3. However, the recording set-up was not sufficiently focused to capture forward-facing images of participants as they played the game. This limited the ability to decode participant's facial expressions and displays for meaningful data analysis. Specifically, because these were naturalistic interactions where people fidgeted and move their body positions relative to the camera, there were many instances in which participants' faces were turned away from the camera and thus, I could not accurately capture the action units. This could have influenced the present results. With better recording control, I might have been able to more closely capture participants' facial behaviour and discovered stronger relationships between behaviour and interpersonal perception.

The results presented in Chapter 4 also use a general movement metric, but this is less of a limitation because here I was interested in overall coordination between interaction partners. As intended, this is captured by the Frame Differencing Method (FDM) presented in this chapter (Paxton & Dale, 2013b). However, for interested readers, a more nuanced analysis of the reciprocity of genuine smiles in the Zoom dyads included in Chapter 4 is presented in Heerey and colleagues (2022).

5.3 Conclusions

These findings demonstrate that the value of social rewards and the perceptive and affiliative functions of nonverbal cues are impacted by the social environment, including social partners, interaction goals, and modalities. Specifically, social media saliency increases the value of social rewards, competitive contexts hinder interpersonal accuracy, and interpersonal coordination is reduced in conversations that occur on video conferencing software, such as Zoom. This highlights the importance of not only reintroducing the general social environment to nonverbal communication research, but also of investigating these effects in diverse social situations.

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Appendices

Appendix A: Pilot Study for Chapter 2 (The Impact of Social Media on the Subjective Value of Social Cues)

This initial proof-of-concept study asked whether thinking about a recent social media post impacts the subjective utility of social rewards by examining the degree to which participants are willing to give up small monetary rewards to see social rewards. We hypothesized that individuals whose recent social media use is called to mind will seek positive social rewards to a greater degree than those whose recent social media use is not. More specifically, we expect that individuals who are thinking about a recent social media post will demonstrate greater subjective desire for genuine smiles and will therefore be more likely to sacrifice the chance to win money for the chance to see a genuine smile, compared to those who have posted recently but are not specifically thinking about their post.

Methods

Participants

Participants completed this study in exchange for partial course credit and a small monetary bonus, based on their performance in a “smile valuation” task. Because this was a proof-of-concept study, we estimated the sample sized based on a small to medium effect. Specifically, we estimated a required sample size of 162 participants using a G*Power analysis for MANOVA (global effects model) with 2 groups and 3 response variables. Estimated parameters included alpha=.05, 1-□=.90 and estimated effect size, $f^2(V)=.09$ (Faul et al., 2007).

To account for the likelihood that some participants would fail to follow task instructions or not respond conscientiously, we recruited a final sample of 182 participants. We subsequently removed nine cases due to inattentive behaviour and invariant responding. Participants were classified as inattentive if they responded faster than 225ms on at least 40% of test trials. We coded invariant responding if participants responded with the same response option for more than 90% of test trials. Our final sample included 173 undergraduates (62 males, M_{age}=19.22, SD=1.38). All participants gave informed consent and the University's Ethics Committee approved all study procedures.

Procedures

When participants signed up for this study, they received an email from our research team asking them to make a post on their preferred social media site approximately 24-hours prior to their study session. They were told that they would be asked questions about this post, such as how many likes and shares it received, but that they would not be asked to discuss the content of the post.

Once participants arrived at the lab and gave informed consent, the computer randomly assigned them to answer a set of questions about their post either immediately before or after completing our smile valuation task. This procedure ensured that experimenters were unaware of participant condition until after data collection was complete. Participants completed the smile valuation task and the social media saliency manipulation exactly as described in the main text. After completing these two tasks and a general measure of social media use, participants were thanked, debriefed, paid, and dismissed. The study session took approximately 30 minutes.

Results and Discussion

Prior to testing our hypotheses, we conducted a one-way ANOVA to determine whether individuals in the pre-task condition differed significantly from individuals in the post-task condition on their social media use. We found no significant group differences on overall social media use, as operationalized by mean scores on the modified SONTUS, $F(1,171)=.15$, $p=.702$. Furthermore, among Facebook, Instagram, and Twitter users, we found no significant group difference in frequency of social media use ($F(1,170)=.16$, $p=.688$) or feedback positivity ($F(1,170)=.82$, $p=.367$).

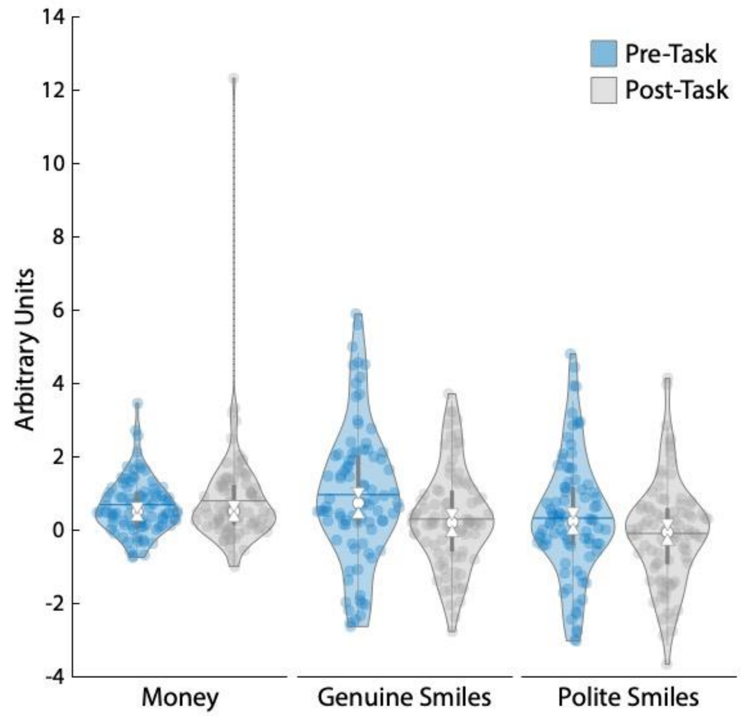

Figure 1. The value of money, genuine smiles, and polite smiles in the pre-task and post-task conditions. Blue fill represents participants in the pre-task condition and grey fill represents participants in the post-task condition. Within each violin, white dots represent the median and the white notches represent the 95%CI of the median; the horizontal lines show the means; the dark grey bars represent the interquartile range (IQR); and the line grey lines represent 1.5 times the IQR. The shape of the violin shows the probability density function of the data distribution. Individual data points are represented by coloured dots.

To test whether social media saliency affects the value of monetary and social rewards, we conducted a MANOVA with pre- versus post-task condition as a fixed factor, and the individually estimated regression weights for monetary rewards, genuine smiles, and polite smiles as the dependent variables. The overall model was significant, Pillai's Trace=.048, $F(3,169)=2.87$, $p=.038$, $\eta_p^2=.048$. Follow-up analyses revealed that participants in the pre-task condition valued genuine smiles significantly more than did those in the post-task condition, $F(1,171)=6.63$, $p=.011$, $\eta_p^2=.037$, 95%CI[.149,1.130](see Figure 1). There were no significant differences between groups for the value of polite smiles ($F(1,171)=3.46$, $p=.065$, $\eta_p^2=.020$, 95%CI[-.027,.898]) or monetary rewards ($F(1,171)=1.08$, $p=.299$, $\eta_p^2=.006$, 95%CI[-.543,.168]).

These results indicate that when participants had a recent social media post in mind, they found genuine smiles to be higher in utility. That is, they were willing to sacrifice monetary gain for the chance to see a genuine smile, whereas individuals who had also made a recent post but had not yet answered questions about it were more reluctant to do so. These results suggest that social media whets people's appetite for social rewards, and rather than leading to social satiety. However, an alternate explanation for these findings is that our manipulation caused participants to look forward to future interactions and thus generally cued them to think about social rewards. This possibility is examined in Studies 1 and 2 (presented in Chapter 2 of this dissertation).

Pilot Study Supplementary Analyses

We conducted a series of exploratory analyses to test for moderation effects in the relationship between social media saliency and the value of genuine smiles. First, we tested whether trait extraversion, operationalized as the average score on the BFI extraversion subscale, moderated this relationship (John & Srivastava, 1999). Here, we conducted a linear regression analysis with condition, extraversion, and the condition x extraversion interaction as independent variables and the individualized regression weights for genuine smiles as the dependent variable. Extraversion scores were not significantly related to the value of genuine smiles (*B*=.56, *t*(169)=1.85, *p*=.066, 95%CI[-.037,1.154]) nor was the interaction between condition and extraversion (*B*=-.74, *t*(169)=-1.68, *p*=.095, 95%CI[-1.60,.129]).

We conducted similar analyses to test for the effects of overall social media usage, operationalized as the average score on the modified SONTUS (Olufadi, 2016), and perceived feedback positivity and satisfaction, operationalized as responses to "to what extent was the feedback you received positive" and "to what extent did the feedback you received meet your expectation". Overall social media usage was not significantly related to the value of genuine smiles (*B*=-.30, *t*(169)=-.62, *p*=.536, 95%CI[-1.266,.661]) nor did the interaction between condtion and overall social media use (*B*=.17, *t*(169)=.55, *p*=.582, 95%CI [-.442,.785]). Furthermore, feedback positivity (*B*=-.02, *t*(167)=-.86, *p*=.391, 95%CI[-.075,.029]) and satisfaction (*B*=.01, *t*(167)=.50, *p*=.618, 95%CI[-.030,.050]) were not significantly related to the value of genuine smiles, nor were the interactions between condition and feedback positivity (*B*=.01, *t*(167)=.31, *p*=.754, 95%CI[-.026,.036]) and condition and feedback satisfaction (*B*=-.00, *t*(167)=-.05, *p*=.961, 95%CI[-.026,.024]).

Appendix B: Chapter 2 Supplementary Analyses

In Study 2, we added a smile discrimination task to establish that participants can differentiate between polite and genuine smiles. Here, we included test trials in which participants viewed familiar faces (i.e., the players in the smile valuation task) and novel faces and asked participants to indicate whether the face was displaying a genuine or a polite smile. We note that participants' ability to discriminate the smiles on the familiar faces was significantly greater than chance (mean d'=3.140, SD=1.919, $p<.001$), suggesting that participants are indeed able to differentiate between the types of smiles within the smile valuation task.

Study 2 also included a rating procedure in which participants explicitly rated the faces that they had played in the game based on "how good they were to play." Table 1 presents correlations between the subjective utility estimates and the face ratings within the full sample. These correlations show that in general, participants' explicit face ratings agree with their choices in the test phase of the task.

Table 1.
Spearman correlations between subjective utility estimates and face ratings.

Expression	**Genuine Smiles**		**Polite Smiles**		**Neutral Faces**	
Value	High-Value	Low-Value	High-Value	Low-Value	High-Value	Low-Value
Monetary Value						
rho:	.214	-.292	.217	-.167	.207	-.226
p-value	<.001	<.001	<.001	<.001	<.001	<.001
95%CI	[.121, .304]	[-.377, -.202]	[.124, .306]	[-.259, -.073]	[.114, .297]	[-.314, -.133]
Genuine Smile Value						
rho:	.288	.281	.059	.129	-.399	-.323
p-value	<.001	<.001	.231	.008	<.001	<.001
95%CI	[.197, .373]	[.190, .366]	[-.037, .153]	[.033, .221]	[-.476, -.315]	[-.406, -.235]
Polite Smile Value						
rho:	.053	.075	.352	.259	-.435	-.358
p-value	.278	.125	<.001	<.001	<.001	<.001
95%CI	[-.043, .148]	[-.021, .169]	[.265, .433]	[.167, .346]	[-.509, -.354]	[-.439, -.272]

We then conducted a series of exploratory analyses to test for moderation effects in both Studies 1 and 2 in the relationship between social media saliency and the value of genuine smiles using the PROCESS macro plug-in for SPSS (Hayes, 2021). We first tested the moderation effect of trait extraversion[10] by assessing the simple slopes using Model 3 in PROCESS macro. For ease of interpretation, we included extraversion as the independent variable with interaction type and saliency as categorical moderators and individualized regression weights for the value of genuine smiles as the dependent variable. Results from Studies 1 ($F(7,412)=5.12$, $p<.001$, $R^2=.08$) & 2 ($F(7,412)=5.88$, $p<.001$, $R^2=.09$) revealed a significant model overall. However, the relationship between extraversion and the value of genuine smiles was not significant in either sample (Study

[10] For Study 1, extraversion was calculated using 7 of the 8 items in the BFI subscale. Item 31 (“is sometimes shy, inhibited”) was not included due to a technical error in recording the data.

1: *B*=.64, *t*(412)=.42, *p*=.677, 95%CI[-.237,.364]; Study 2: *B*=.07, *t*(412)=.57, *p*=.572, 95%CI[-.179,.323], nor was the three-way interaction between interaction type, saliency, and extraversion (Study 1: *B*=-.25, *t*(412)=-.83, *p*=.409, 95%CI[-.856,.349]; Study 2: *B*=.05, *t*(412)=.16, *p*=.871, 95%CI[-.518,.612]. Overall this suggests that there was no evidence of a moderation effect in either sample.

We conducted a similar analysis with the average score on the modified SONTUS (Olufadi, 2016) as the independent variable. The overall model was significant for both studies (Study 1: *F*(7,412)=4.54, *p*<.001, R^2=.07; Study 2: *F*(7,412)=6.99, *p*<.001, R^2=.11). In Study 1, overall social media use was not significantly related to the value of genuine smiles (*B*=-.18, *t*(412)=-1.06, *p*=.283, 95%CI[-.518,.152]), whereas in Study 2 overall social media use was significantly related to the value of genuine smiles, such that for each unit increase in overall social media use, the value of genuine smiles decreased by -.41 (*B*=-.41, *t*(412)=-2.07, *p*=.039, 95%CI[-.803,-.022]. However, the three-way interaction between interaction type, saliency, and social media use was not significant in either sample, indicating that there is no moderation effect (Study 1: *B*=.21, *t*(412)=.62, *p*=.536, 95%CI[-.464,.892]).

Because previous research has suggested that self-reported need to belong predicts social media use, we assessed this relationship within our samples (Knowles et al., 2015). Here, we conducted a linear regression analysis with need to belong, operationalized as the average score on the Need to Belong Scale (Leary et al., 2013), as the independent variable and overall social media use, as operationalized by the modified SONTUS (Olufadi, 2016), as the dependent variable. The overall model was significant in both Study 1, *F*(1,401)=25.58, *p*<.001, and Study 2, *F*(1,418)=20.70, *p*<.001. More specifically, in Study 1 we found that for each unit increase in need to belong, there is a .39 unit increase in overall social media use (*B*=.39, *t*(401)=5.06, *p*<.001, 95%CI[.240,.545]) and in Study 2 we found that for each unit increase in need to belong, there is a .20 unit increase in overall social media use (*B*=.20, *t*(418)=4.55, *p*<.001, 95%CI[.116,.292]. This replicates previous findings that suggest positive relationship between need to belong and social media use (Knowles et al., 2015).

After establishing a relationship between need to belong and overall social media use within our sample, we tested how these variables influenced the value of genuine smiles. Here, we used PROCESS macro model 1, with need to belong as the independent variable, overall social media use as the moderator, and the value of genuine smiles as the dependent variable. In both samples, the overall model was not significant (Study 1: $F(3,399)=1.38$, $p=.248$, $R^2=.01$; Study 2: $F(3,416)=2.17$, $p=.089$, $R^2=.02$), which indicates that neither variable significantly influenced the subjective value of genuine smiles. Because there is no evidence of a relationship between these variables, we did not interpret the rest of the model.

Evidence suggests that active social media use aimed at increasing social connection mitigates feelings of loneliness (Deters & Mehl, 2013). We therefore conducted correlational analyses on average scores on the Revised UCLA Loneliness Scale (Russell et al., 1980) and various social media activities in Study 2. In general, people who report more active engagement, positive feedback, and feedback satisfaction on social media are less lonely (see Table 2). However, regardless of the mitigating effect that social media has on loneliness, it is unrelated to people's responses to monetary rewards ($r=-.04$, $p=.406$), polite smiles ($r=-.05$, $p=.678$), and genuine smiles ($r=.02$, $p=.678$) in the task.

Table 2.
Correlations between loneliness and social media activities.

		Loneliness
Activity on participants' posts	Likes	r=-.20, p<.001
	Comments	r=-.21, p<.001
	Shares	r=-.11, p<.024
	Feedback Positivity	r=-.22, p<.001
	Satisfaction with Audience	r=-.30, p<.001
	Satisfaction with Feedback	r=-.32, p<.001
Participant activity on other people's posts	Likes	r=-.11, p=.023
	Comments	r=-.13, p=.006
	Shares	r=-.03, p=.556

We also tested for the moderating effects of feedback positivity and feedback satisfaction on the relationship between saliency and the value of genuine smiles for those who posted on social media. Here, we conducted a linear regression analysis with saliency, feedback positivity, feedback satisfaction, and the interactions between feedback positivity and saliency, and feedback satisfaction and saliency as the independent variables and the individualized regression weights for genuine smiles as the dependent variable. Neither feedback satisfaction (Study 1: B=-.00, $t(202)$=-.34, p=.734, 95%CI[-.016, .012]; Study 2: B=-.02, $t(205)$=-1.93, p=.055, 95%CI[-.031,.000]) nor its interaction with saliency (Study 1: B=-.01, $t(202)$=-.68, p=.495, 95%CI[-.027,.013; Study 2: B=.01, $t(205)$=1.32, p=.184, 95%CI=-.007,.035]) were significantly related to the value of genuine smiles. In Study 1, feedback positivity was related to the value of genuine smiles, such that receiving more positive feedback on one's social media post was associated with a higher utility for genuine smiles, B=.01, $t(202)$=1.98, p=.049, 95%CI [.000,.027], but not in Study 2 (B=.01, $t(205)$=.86, p=.390, 95%CI[-.008,.022] . However, there was no evidence of a moderation effect because the interaction between feedback positivity and saliency was not significant in either sample (Study 1: *B*=-.01, *t*(202)=-1.48, *p*=.141, 95%CI[-.033,.005]; Study 2: *B*=-.00, *t*(205)=-.41, *p*=.685, 95%CI[-.023,.015]). Because there were no group differences on the value of genuine smiles for individuals who were assigned to have a conversation, we did not run similar analyses on the equivalent items for those groups.

The final exploratory analysis we conducted examined whether there were differences between those who had their conversation face-to-face versus on a video chat software. We found no differences between modalities on how positive the conversation made them feel or the degree to which the conversation met their expectations (see Table 3). We then tested for differences in the value of genuine smiles based on whether those assigned to have a conversation did so face-to-face or on a video call software. In Study 1, there was a main effect of the modality of the conversation, such that those who had a conversation as a video call rather than a real face-to-face interaction, showed slightly greater utility for genuine smiles, $F(1,205)=3.98$, $p=.047$, $\eta_p^2=.019$. However, this effect did not replicate in Study 2, $F(1,205)=.02$, $p=.893$, $\eta_p^2=<.001$. There was no main effect of saliency (Study 1: $F(1,205)=.04$, $p=.842$, $\eta_p^2<.001$; Study 2: $F(1,205)=.18$, $p=.673$, $\eta_p^2=.001$), nor was there evidence of a significant interaction the modality of the conversation and saliency (Study 1: $F(1,205)=.74$, $p=.392$, $\eta_p^2=.004$; Study 2: $F(1,205)=.07$, $p=.800$, $\eta_p^2<.001$) in either sample.

Table 3.
Reported levels of positive feelings within the conversation and the degree to which the conversation met expectations depending on whether it occurred via video chat or face-to-face.

	Study 1				Study 2			
	Video (N=94)	F-t-F (N=115)	F (1,207)	p	Video (N=64)	F-tF (N=145)	F (1,207)	p
Positivity	78.82 (21.28)	74.82 (21.28)	1.12	.292	79.78 (21.33)	77.50 (22.51)	.469	.494
Met Expectations	70.89 (18.74)	68.77 (19.08)	.66	.417	71.48 (18.76)	71.03 (20.81)	.023	.880

Appendix C: Video Consent Form Used in Chapter 3

As you know, the primary purpose for video recording the interactions is so that we can answer research questions related to how people use different social and behavioural cues to create perceptions of different people. You have agreed that we may use your video record for this purpose. However, we sometimes use videos for other purposes such as training other researchers in data analysis, demonstrating our experimental procedures in seminars, and presenting our findings at conferences. Please decide which (if any) of the following possible uses of your video you consent to by affirming or denying each. You may consent to as many or as few of these uses as you wish. We will only use your video recordings in ways that you have consented to. You may still participate in the study, even if you do not consent to any of these additional possible uses of your video. Note that consenting to these items does not guarantee that your videos will be used in these ways.

1) My videos may be used within the lab to help train future research assistants in research techniques (within the 7-year data retention period).
2) My videos may be viewed and coded for measured of interaction quality by other participants in future studies (within the 7-year data retention period).
3) My videos (or still photos from them) may be shown to other researchers at conference/seminar presentations (within the 7-year data retention period; note that this means that one or more videos/images including you may leave protected institutional servers).
4) My videos (or still photos from them) may be included in published articles and thesis materials (note that this means that one or more videos/images including you may leave protected institutional servers and that these videos/images may exist permanently in the public domain).
5) My videos may be shown to the general public as part of research reports or media stories detailing our findings (note that this means that one or more videos/images including you may leave protected institutional servers and that these videos/images may exist permanently in the public domain).

6) My videos may be shown to interested students at Western University in the context of social psychology classes (note that this means that one or more videos/images including you may leave protected institutional servers and that these videos/images may exist permanently in the public domain).

Appendix D: Post-Game Questionnaire Used in Chapter 3

1) In this game I was:
    - A member of Dumbledore's Army
    - A Death Eater
2) Did your team win?
    - Yes
    - No
3) How much did you enjoy this round of the game?
    - A great deal
    - A lot
    - A moderate amount
    - A little
    - Not at all
4) How has your mood changed in comparison to before this game round?
    - Significantly more negative
    - Slightly more negative
    - Neither more negative nor more positive
    - Slightly more positive
    - Significantly more positive
5) Did you lie to try to win?
    - Yes
    - No
6) Did you attempt to conceal or withhold information from the other players to try to win?
    - Yes
    - No
7) Was the player at Hogwarts Express a Death Eater?
    - Yes
    - No

8) How confident are you with your decision regarding the role of the player at Hogwarts Express?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
9) Did the player at Hogwarts Express lie to try to win?
    - Yes
    - No
10) How confident are you with your decision about whether the player at Hogwarts Express lied?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
11) Was the player at Hogwarts Castle a Death Eater?
    - Yes
    - No
12) How confident are you with your decision regarding the role of the player at Hogwarts Castle?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
13) Did the player at Hogwarts Castle lie to try to win?
    - Yes
    - No

14) How confident are you with your decision about whether the player at Hogwarts Castle lied?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
15) Was the player at Gringotts Bank a Death Eater?
    - Yes
    - No
16) How confident are you with your decision regarding the role of the player at Gringotts Bank?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
17) Did the player at Gringotts Bank lie to try to win?
    - Yes
    - No
18) How confident are you with your decision about whether the player at Gringotts Bank lied?
    - Completely confident
    - Somewhat confident
    - Not sure
    - Somewhat unconfident
    - Completely unconfident
19) Was the player at Quidditch Pitch a Death Eater?
    - Yes
    - No

20) How confident are you with your decision regarding the role of the player at Quidditch Pitch?

- Completely confident
- Somewhat confident
- Not sure
- Somewhat unconfident
- Completely unconfident

21) Did the player at Quidditch Pitch lie to try to win?

- Yes
- No

22) How confident are you with your decision about whether the player at Quidditch Pitch lied?

- Completely confident
- Somewhat confident
- Not sure
- Somewhat unconfident
- Completely unconfident

23) Was the player at the Forbidden Forest a Death Eater?

- Yes
- No

24) How confident are you with your decision regarding the role of the player at the Forbidden Forest?

- Completely confident
- Somewhat confident
- Not sure
- Somewhat unconfident
- Completely unconfident

25) Did the player at the Forbidden Forest lie to try to win?

- Yes
- No

26) How confident are you with your decision about whether the player at Forbidden Forest lied?

- Completely confident
- Somewhat confident
- Not sure
- Somewhat unconfident
- Completely unconfident

Appendix E: AME Model for Group 1

```
library(amen)

#outcome
data = read.csv(file = 'Group1_Y.csv')
Y = array(dim=c(5, 5, 3))
for (row in 1:nrow(data)) {
    Y[data[row,'Perceiver'], data[row,'Target'], data[row,'Round']] = data[row,'acc']
  }
print(Y)

#X
data2 = read.csv(file = 'Group1_Node.csv')
X = array(dim=c(5, 4, 3))
for (row in 1:nrow(data2)) {
  X[data2[row,'Perceiver'], 1, data2[row,'Round']] = data2[row,'Movement']
  X[data2[row,'Perceiver'], 2, data2[row,'Round']] = data2[row,'Role']
  X[data2[row,'Perceiver'], 3, data2[row,'Round']] = data2[row,'Extraversion']
  X[data2[row,'Perceiver'], 4, data2[row,'Round']] = data2[row,'Length']
}
print(X)

n<-dim(X)[1];t<-dim(X)[3]

#nodal covariates
Xnode<-X[,1:3,]
Xnode<-array(Xnode,dim=c(n,ncol(Xnode),t))
dimnames(Xnode)[[2]]<-c("Movement","Role", "Extraversion")
Xnode

#dyadic covariates
Xdyad<-array(dim=c(n,n,2,t))
```

```
Xdyad[,,1,1]<-array(X[,4,1], dim=c(n,n)) #video length at time 1
Xdyad[,,1,2]<-array(X[,4,2], dim=c(n,n)) #video length at time 2
Xdyad[,,1,3]<-array(X[,4,3], dim=c(n,n)) #video length at time 3
Xdyad[,,2,1]<-(Y[,,1])
Xdyad[,,2,2]<-(Y[,,2])
Xdyad[,,2,3]<-(Y[,,3])
dimnames(Xdyad)[[3]]<-c('Length', 'Time')
Xdyad

#ame
fit<-ame_rep(Y,Xdyad,Xnode,Xnode,family="ord",symmetric=FALSE)
summary(fit)
```

Appendix F: JASP Syntax for APIM Liking Model

Note: Syntax for the model was adapted from a Shiny web app developed by L. Stas, D.A. Kenny, A. Mayer, and T. Loeys (2018)

```
p1_likingRating ~ a*ave_P1auto
p2_likingRating ~ a*ave_P2auto
p1_likingRating ~ p*ave_P2auto
p2_likingRating ~ p*ave_P1auto
ave_P1auto ~ mx*1
ave_P2auto ~ mx*1
p1_likingRating ~ my*1
p2_likingRating ~ my*1
ave_P1auto ~~ vx*ave_P1auto
ave_P2auto ~~ vx*ave_P2auto
p1_likingRating ~~ vy*p1_likingRating
p2_likingRating ~~ vy*p2_likingRating
ave_P2auto ~~ cx*ave_P1auto
p2_likingRating ~~ cy*p1_likingRating
p1_likingRating ~ bc11*ave_xCorr
p2_likingRating ~ bc12*ave_xCorr
ave_xCorr~~vbc1*ave_xCorr
ave_xCorr~mbc1*1

k := p/a
sum := (p + a)/2
cont := a – p
```

Appendix G: JASP Syntax for Interaction Quality Model

Note: Syntax for the model was adapted from a Shiny web app developed by L. Stas, D.A. Kenny, A. Mayer, and T. Loeys (2018)

```
p1_QIrating ~ a*ave_P1auto
p2_QIrating ~ a*ave_P2auto
p1_QIrating ~ p*ave_P2auto
p2_QIrating ~ p*ave_P1auto
ave_P1auto ~ mx*1
ave_P2auto ~ mx*1
p1_QIrating ~ my*1
p2_QIrating ~ my*1
ave_P1auto ~~ vx*ave_P1auto
ave_P2auto ~~ vx*ave_P2auto
p1_QIrating ~~ vy*p1_QIrating
p2_QIrating ~~ vy*p2_QIrating
ave_P2auto ~~ cx*ave_P1auto
p2_QIrating ~~ cy*p1_QIrating
p1_QIrating ~ bc11*ave_xCorr
p2_QIrating ~ bc12*ave_xCorr
ave_xCorr~~vbc1*ave_xCorr
ave_xCorr~mbc1*1

k := p/a
sum := (p + a)/2
cont := a - p
```

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