Synchrony and Visual Perspective Taking: An investigation of the relationship and the roles of Similarity and Prediction

By

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Abstract

Synchronous action is motor behaviour aligned to an external cue and is distinct from other forms of coordination due to the specific temporal requirement. Synchrony increases trust, cooperation, facilitates group cohesion and can extend our representation of 'self' to include an inanimate object or even another person. How synchrony influences cognition and how it interferes with our sense of 'self' and 'other' to support social interactions, has not been investigated previously.

A core cognitive mechanism underlying social interactions, Level-1 Visual Perspective Taking (VPT), is the ability to take on the visual perspectives of others and relies on suppression of one's own perspective. This investigation expands the research into how social information about the perspective taking target can influence VPT, through the inclusion of synchronous action.

Using the 'dot perspective' task, this investigation found that prior social information about a target interferes with VPT in differing ways. Synchrony reduced egocentric intrusions, potentially leading to overlap of 'self' and 'other' perspectives. Synchronised action increased perceived understanding of the mental states of others, which may enable pro-social outcomes. Inclusion of a control condition highlighted that social information from an asynchronous coordination is better than no engagement. Examination of the influence of predictability within coordination emphasised the importance of prediction in a social interaction. Further, that being an asynchronous 'follower' provides stronger social information than being a 'leader' responsible for maintaining action.

Similarity, a synchrony outcome, was seen to be inhibitory to perspective-taking. Expectations of dissimilarity made participants more considerate of the 'other' perspective. Combination of coordination and similarity cues highlighted the complexities of internally balancing social information during interactions.

Synchrony does not just have socio-emotional outcomes. It influences our cognitions making us better able to take on the perspective of others, to achieve the mutual goal of positive social interaction.

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Author's Declaration

The research for this thesis was conducted while the author was a full-time postgraduate student in the School of Psychology at the University of East Anglia, Norwich (October 2020-September 2024) on a studentship from the University of East Anglia.

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas, and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the School of Psychology Ethics Committee at the University of East Anglia.

Chapter 1

Introduction

1.1 Introduction Overview

Effective interpersonal communication is reliant on successful interpersonal coordination, where our speech, attention and behaviours are coordinated with those of others. Social interactions are dependent on coordination which relies on mentalising the other person and recognising that they have independent mental states, thoughts and feelings from our own (Premack & Woodruff, 1978). This is characterised in human ability to interpret the behaviour of others as well as predict future behaviours through internal representations of their mental states (Apperly, 2010). These are kept separate from our own 'self' representation.

Synchrony is a distinct form of interpersonal coordination which requires temporal alignment; it is the prediction and action of a behaviour in the exact same instance as another person (Sebanz, Bekkering, & Knoblich, 2006). As such, synchronising with others impacts how we relate to each other and how we perceive one another. Engagement in synchrony has been used throughout history to form social bonds, facilitate group cohesion and build community (Launay, Tarr, & Dunbar, 2016; Macrae, Duffy, Miles, & Lawrence, 2008). Further, the social, emotional and cognitive effects of synchrony are experienced whether synchronous action is engaged with intentionally, unintentionally, or artificially. The social and emotional outcomes of interpersonal synchrony, such as increased perceptions of similarity to synchronous interactants, are well established (Rabinowitch & Knafo-Noam, 2015).

Research has found that synchronised action can result in the extension of 'self' representation to include inanimate objects and people (Paladino, Mazzurega, Pavani, & Schubert, 2010; Cardinali, et al., 2021; Reddish, Tong, Jong, & Whitehouse, 2020). However, how synchronised action might influence cognitive processes involving mental representations of 'self' and 'other' within a social context beyond sense of ownership and agency has not been examined.

This investigation focuses on a core cognitive mechanism which underlies social interactions, Level-1 Visual Perspective Taking (VPT). VPT is the ability to take on the visual perspective of another person. VPT is reliant on suppression of our own perspective. This mechanism has been posited to occur outside of cognitive control as illustrated by the 'dot perspective task' (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). This investigation expands the research into how social information, in the form of synchronous action, about a 'perspective taking target' can influence VPT. This investigation will also examine how similarity will influence VPT in isolation and in combination with interpersonal

coordinated action. Finally, this investigation explores the effects of predictability, the degree to which a correct prediction can be made of the actions of another, within interpersonal coordination.

1.2 Social Cognition

In 1998, Robin Dunbar first published what would become 'The Social Brain Hypothesis' in Evolutionary Anthropology Journal (Dunbar, 1998). It proposed a possible explanation for why primates have unusually large brains for their body size compared to other animals. Dunbar suggested that this was an evolutionary response, that large brains were necessary for management of unusually complex social systems. The core principle of evolutionary psychology is that there is a balance of cost and benefit. Our brains are costly systems, which are unlikely to evolve without purpose or a socio-environmental demand. Therefore, there must have been an evolutionary need for brain growth. Almost a decade later, Dunbar wrote a summary for the Encyclopaedia of Neuroscience. In this, he notes how group size, amongst other things, can be limited by abilities to maintain social relationships (Dunbar, 2009). Additionally, he postulated that it is social *complexity* which requires a larger brain, rather than just being social. This is proven by the importance of developing our communication as we grow, which is how we create and manage social relationships. A socially complex brain is dependent on the time that can be invested into socialization, as evidenced by the development of social skills during infancy to adolescence. The human brain evolved to support socially complex relationships, and the social cognitive mechanisms required to maintain them. Moreover, it has evolved to allow some of these social cognitive mechanisms to be employed for beneficial consequences without conscious awareness or effort. How exactly the neural systems in the brain translates to observable behaviour is a continuing area of research. As such, our understanding of social cognition continues to develop.

Historically in scientific research, there has been a tendency to study phenomena in isolation. However, our cognitions do not respect these boundaries, especially within a social context. There was once an assumption that perceiving and performing actions were distinct processes in the brain, but the existence of mirror neurons in the premotor cortex counter this, as they are firing both when observing and when executing an action (Rizzolatti, 2005). Even hearing unobserved sounds engage motor regions of the brain when they are attributed to the actions of another person, (Gazzola, Aziz-Zadeh, & Keysers, 2006). As such, perception,

action and cognition cannot be studied in isolation if we are to understand the mechanisms involved in interpersonal interactions. Social interactions must therefore be approached as multiple complex dynamic systems engaging together (Richardson & Chemero, 2014).

One necessary specialised process for social cognition is our ability to 'mentalise' others, also referred to as 'Theory of Mind'. The term of 'Theory of Mind' (ToM) was first coined in a journal article about nonhuman primates, referring to their ability to infer the intentions of others (Premack & Woodruff, 1978). Much has been documented about ToM, but the details of the underlying cognitions are relatively unknown. It could be a combined product of basic executive functions (memory, causal reasoning, sensory information processing), it could be a "specialized cognitive module", or it could be a combination of many other highly developed cognitive abilities and mechanisms, which align to focus on a single problem. If we take ToM, or even all social cognition to be the latter combination, an emergent property from the engagement of a number of cognitive mechanisms, then it raises the question of how these cognitive mechanisms interact and influence one another and what the social outcomes might be, both in social relationships and in brief social interactions. Mentalising others is broadly the acknowledgment that they are independent from oneself and can therefore have different beliefs, goals, thoughts and intents. To understand the minds of others, we must construct a representation of their mental states in our minds. Subsequently, a core facet of ToM is being able to distinguish what you know from what others know. As almost all tests of ToM are not applicable to neurotypical adults in social contexts, research into mentalising can be broken down into our abilities of representing the minds and taking on the perspectives of others (Quesque & Rossetti, 2020). Distinguishing the 'other' from the 'self' enables communication, necessary for all aspects of life and communication requires coordination.

1.3 Interpersonal Coordination

Coordination is essential for interpersonal interactions as all communication is dependent on the coordination of behaviours (Cappella, 1997). Our ability to have smooth or fluent interactions with other people requires us to coordinate our behaviour with theirs. Even conscious deviation from coordination constitutes communication. Interpersonal coordination provides behavioural cues that enable shows of attention, interest or concern as appropriate, which subsequently facilitates positive and effective social interactions. As such, rhythmic interpersonal coordination relies on three core cognitive motor skills: anticipation, attention and adaptation. All interactants must have the ability to predict the other's action, attend to

when and how it will occur and adapt accordingly on a millisecond time scale (Keller, Novembre, & Hove, 2014). However, the abilities are reliant on cognitive integration of self-knowledge which forms our mental representation of self and can guide our creation of a mental representation for the other. Increased coordination improves our ability to anticipate, attend and adapt to the 'other' and consequently adapt coordination more as coordination changes with context (Romero & Paxton, 2023).

Rhythmic joint action requires both temporal precision and flexibility, challenging the cognitive motor systems of interactants (Keller, Novembre, & Hove, 2014). Successful cooperative joint action is dependent on flexible and reliable adaptation between individuals because enhanced processing of perception and action increases our accuracy in predicting the minds of others (Sebanz & Knoblich, 2021). Joint action requires using mental representations to predict and balance the contributions of two or more interactants. Bolt and Loehr (2017) had participants produce an 8-tone action sequence with two separate partners, where the timing was manipulated so that one partner was more predictable. Participants felt stronger joint agency with the more predictable partner as they were better able to coordinate their own behaviour. The predictability of the partner influenced feelings of joint agency, even independent of the participants' own action timing which would instead provide a sense of self-agency. Predicting the behaviours of others and incorporating those predictions into our own action planning is essential for joint action. It has even been proposed that in preparing for joint action, both individual and group level 'we' representations are formed (Kourtis, Woźniak, Sebanz, & Knoblich, 2019). However, joint action is often goal-oriented whereas coordination can be spontaneous actions embodied by social cognitions which occur naturally in interactions.

1.4 Synchrony

Synchrony, even to the uninformed observer, is distinct from other forms of interpersonal coordination regardless of format. Mimicry involves corresponding behaviour after a short delay, whereas synchrony has the complexity of requiring temporal alignment between interactants. Mimicry entails the perception of a behaviour and then acting that same behaviour, whereas synchrony relies on anticipation of the behaviour, such efficient prediction that the action can occur in the exact same instance as that of the other person (Sebanz, Bekkering, & Knoblich, 2006). Furthermore, synchrony is dynamic and occurs in multiple formats, including action, attention, and speech (Newman & Newman, 1991). Mayo and

Gordon (2020) claim that to have an adaptive interpersonal system within a social context, individuals must have two simultaneous tendencies: to achieve interpersonal synchrony and to switch in and out of interpersonal synchrony. Unlike most species, humans engage in behavioural synchrony in order to promote neural synchrony and subsequent social bonding (Wheatley, Kang, Parkinson, & Looser, 2012). More coordination can result in a reduction of activity in cognitive control brain areas and increase in brain regions associated with socio-emotional processes (Fairhurst, Janata, & Keller, 2013). Synchrony creates a state of processing fluency, implying successful social interaction to those involved. However, it is unclear how this occurs.

We can become conscious that we are engaging in synchrony ("Hey look we're walking in step together!"), however, we do not need intent or awareness to synchronise. Unintentional synchrony can often occur when there are clearly defined social norms and naturally emerge from feelings of successful fluid interactions. Conversational partners will make matching gestures in time with each other (Louwerse, Dale, Bard, & Jeuniaux, 2012). After only a few seconds of clapping randomly, theatre and opera audience will begin to synchronize (Néda, Ravasz, Brechet, Vicsek, & Barabási, 2000). We need only to perceive and attend to another person to act synchronously, which implies that there is purpose and benefit to do so. Tarr, Launay, Cohen and Dunbar (2015) found that moving together in unison releases endorphins which shows activation of the brains rewards system. Further, if we look to instances of intentional synchrony, we can see why we are inclined to synchronise even outside of our awareness.

1.5 Social Effects of Synchrony

Cultural practices and rituals involving synchrony may have been used to give community groups a societal evolutionary advantage. Synchronous action leads to an increase in cooperation and individuals acting in interest of the group rather than self. Evolutionarily speaking, this then reduces the possibility of 'free loaders' who may take advantage of the group without providing support or resources in turn. Synchrony can function as an adaptive mechanism which can be used to manage a large social network, connect to a whole community rather than specific individuals within it (Launay, Tarr, & Dunbar, 2016). In the 21st century we still see numerous examples of the use of synchronous action to increase group cohesion and social bonding; the Māori Haka, soldiers marching, even doing the macarena at a wedding (Zimmermann & Richardson, 2016). The effects of synchronous action goes so far that we pay

less attention to others that are moving asynchronously to us (Reddish, Fischer, & Bulbulia, 2013). Synchrony has endured in providing a non-verbal route for interpersonal connections to form, both in direct dyadic interactions and when scaled up to a large group.

Experimental research investigations into the effects of synchrony tend to involve less exertive movements than dancing, such as finger tapping, rocking in a chair or arm movements, but nonetheless show that synchronising with others influences feelings towards them (Valdesolo & DeSteno, 2011; Wiltermuth & Heath, 2009; Reddish, Tong, Jong, & Whitehouse, 2020). Valdesolo, Ouyang and DeSteno (2010) used rocking chairs to manipulate movement synchronously and asynchronously, before engaging in perceptual sensitivity and joint action tasks. The rocking chairs were ostensibly present to measure their heartbeat. In the synchronous condition, the rocking chairs were seated side by side and participants were explicitly told to rock in synchrony. Whereas in the asynchrony condition they were positioned in chairs that were back-to-back, to minimise occurrence of unintentional synchrony. Richardson, Marsh, & Schmidt (2005) found that sitting adjacent and swinging pendulums were sufficient interactant presence and visual information to induce unintentional rhythmic coordination.

Interpersonal synchrony has been found to increase cooperation, rapport, trust, pro-social behaviour and collaborative problem solving (Zimmermann & Richardson, 2016; Miles, Nind, & Macrae, 2009; Mogan, Fischer, & Bulbulia, 2017; Lakens & Stel, 2011). Synchrony increases feelings of mutual affiliation between interactants, even improving memory recall of their interactants appearance and utterances (Hove & Risen, 2009; Macrae, Duffy, Miles, & Lawrence, 2008). Engagement in synchrony can even amplify pro-social feelings and behaviour to people who did not participate (Reddish, Bulbulia, & Fischer, 2014). Further, stable synchrony was most pronounced when participants interacted with an out-group member, highlighting synchrony as a means to lessen social distance and perceived differences (Miles, Lumsden, Richardson, & Macrae, 2011). The social effects of synchrony can be so powerful that synchronising to a sound, which participants had been told was made by another person increased likeability of that person (Launay, Dean, & Bailes, 2014). Despite the absence of physical human presence due to the online nature of Launay, Dean and Bailes's study, or even visual evidence that the sound was from human action, the participants treated the sound as an interaction partner when believed it was made by a person they were shown briefly.

Synchronising with someone can also influence perceptions of self. Interpersonal synchrony has been found to increase self-esteem and improve mental wellbeing (Lumsden,

Miles, & Macrae, 2014; Stewart & Lonsdale, 2016). Ramseyer & Tschacher (2011) found that initial movement synchrony between client and therapist was predictive of clients' experience of quality of therapeutic alliance at the end of the session. This included perception of relationship quality and symptom reduction. They also found that nonverbal synchrony was higher in genuine social interactions compared with the pseudo-interaction control condition. Synchrony is an incredibly powerful social signal, affecting ourselves as well as others. Synchronous interactions, in comparison with asynchronous interactions, increase self-reported tendencies for considering the mental states of others (Baimel, Birch, & Norenzayan, 2018). Further, as stated above, synchronising with a partner improved memory recall of what the partner said, whereas moving out of synchrony with the partner improved memory of self-produced words (Macrae, Duffy, Miles, & Lawrence, 2008; Miles, Nind, Henderson, & Macrae, 2010).

Synchrony can build community; however, it is not guaranteed. Synchronisation can decrease if there is some negativity within an interaction, such as a tardy partner or feelings of tension (Miles, Griffiths, Richardson, & Macrae, 2010; Paxton & Dale, 2013). Whilst the reduction in movement coordination might be unconscious, failing to synchronise can cause discomfort or distrust of the other person (Schoenenberg, Raake, & Koeppe, 2014). Synchrony is an adaptive process; it can occur unintentionally, but it can also be inhibited outside of our conscious awareness. Subsequently, failing to synchronise must have cognitive influence over our social interactions as well.

1.6 Cognitive Effects of synchrony

The social and emotional effects of synchrony are well documented in the literature. However, there remains a lack of knowledge surrounding how behavioural and interpersonal synchrony will influence our cognitions. There is some research evidencing that synchrony seems to be able to influence our perceptions of self and other. Wheatley, Kang, Parkinson, and Looser (2012) suggested that synchrony weakens our internal computation of the other person as an entity separate to us. Behavioural synchrony allows for synchronised mental representations of own and other behaviour, which reduces both the brains processing load and aids in reducing possible errors in predicting future behaviour of others (Koban, Ramamoorthy, & Konvalinka, 2019). However, the effects of synchrony on forming mental representations of the self and the other are unclear, in terms of social interactions. That said, we do have some understanding of how synchrony can impact our sense of self.

We are aware of our ownership over our body and the limitations of it (Martin, 1992). Despite our awareness of the boundaries of our body it has been proven to be relatively easy to induce the illusion of ownership to fake body parts, such as in the rubber hand illusion (Botvinick & Cohen, 1998). In this, the participants hand is hidden from them but brushed in synchrony with a fake hand that they can see which leads the participant to report the fake hand belongs to them. The illusion is entirely contingent on synchrony, any temporal delays drastically reduce the effects (Costantini & Haggard, 2007). Previously, it has been argued that visual resemblance has also been a requirement of the study, but more recent research has found that artificial objects, such as a mechanical grabber, can also become embodied (Cardinali, et al., 2021). The illusion is not limited to synchronous brushing and can be induced by synchronous movement, despite conscious feelings of ownership being absent (Romano, Caffa, Hernandez-Arieta, Brugger, & Maravita, 2015). Synchrony induced illusions of ownership are strongly affected by perceptual agency rather than similarity (Ma & Hommel, 2015). The illusion is also characterised by synchronously engaged participants perceiving the location of their hand being closer to the embodied tool/fake hand, showing that synchronous movement can create perceptual extensions of our self-representation, our sense of ownership and agency can expand.

This effect is not just limited to inanimate objects. Paladino, Mazzurega, Pavani, & Schubert (2010) investigated how the perception of self-other merging induced by synchronous brushing would apply to other people. Participants were stimulated being brushed on the cheek whilst watching a video of another person, who was also being brushed on the cheek, either synchronously or asynchronously to the participant. They found evidence of cognitive self-other overlap through multisensory stimulation, the perceived boundaries of ‘self’ and ‘other’ became blurred with synchronous brushing even if the ‘other' was a stranger. The synchronous ‘other’ was perceived by participants as closer more similar to them, even in terms of personality. Lumsden Miles and Macrae (2014) also found an increased perception of self-other overlap following engagement in synchrony with the confederate. However, it should be noted that the perceptual self-other overlap occurred inwards, the ‘other’ merged to the ‘self’. This has not consistently been found to be the case.

Jasmin et al., (2016) used functional magnetic resonance imaging (fMRI) to investigate neural activity in synchronised speech and found that there was not a suppression of sensory cortices, which is a neural marker of self-production, during joint synchronous speech. Synchrony resulted in the action being processed as ‘other’ rather than ‘self’ produced. This

connects to the findings of Reddish, Tong, Jong and Whitehouse (2020) who investigated whether the effects of the rubber hand illusion and the self-other merging of brushed faces could lead to extended self-agency following interpersonal synchrony. Rather than the participants being stimulated in synchrony, they acted in synchrony. Participants moved their arm to a metronome beat whilst being shown a video of a confederate "second participant" also moving their arm either in synchrony or asynchronously to the beat that the participant was moving to. They found that synchrony, but not asynchrony, influenced the participants' perceived extended self-agency over the other person. However, they also found perceptions of extended other-agency over the self, following synchrony. They repeated the experiment, manipulating the timing and found that participants' sense of extended self-agency increased when perceived to be leading, but sense of extended other-agency increased when they perceived themselves to be following the other person. The authors argue that synchrony created a sense of joint-agency and that interpersonal synchrony might modulate core elements of our mental representations of 'self'.

These findings indicate that synchrony can strongly affect our concept of 'self'. Further, that our mental representation of others may be brought closer to our sense of self, even merge with it. However, the literature in this area primarily considers ownership and agency of behaviour and fails to consider ways in which synchrony is used, in social interactions.

1.7 Perspective Taking

Social interactions are reliant on our ability to distinguish the other person from ourselves and infer their mental states. Humans are inherently egocentric, and we process the world around us in relation to ourselves. It is possible to be certain of our own perspective, but we can never be completely definitive on the thoughts, feelings, or perceptions of others. One theory underlying perspective taking is the 'Anchoring and Adjustment' heuristic (Tversky & Kahneman, 1974). Here we begin with our own egocentric perspective, which acts as an anchor from which we adjust to the altercentric, other, perspective. This process is evidenced in egocentric biases increasing during tasks under time pressure and decreasing when these tasks involve incentives for accurate responses in addition to habitual insufficient adjustment when a 'plausible estimate' is reached (Epley, Keysar, Van Boven, & Gilovich, 2004; Epley & Gilovich, 2006). To take on an altercentric perspective is to step into someone else's shoes and attempt to view the world as they might.

There are two main processes of perspective taking within social interactions: embodiment and mentalising. Embodiment in social cognition emphasises the connection between perception and action in our cognitive functioning, that our mental states are grounded in our physical states (Lakoff & Johnson, 1999). Our subjective feelings can affect our perceptions, which has been found to be true on a visceral level as bodily sensations can affect perceptions of the world and others. Risen and Critcher (2011) found that visceral states made corresponding states of the world easier to simulate (e.g. feeling warm influences belief in global warming) and therefore appears more plausible. The primary argument of embodiment is that our brain is not the only resource we use to process the world around us and that our bodies can act in place of complex mental representations of ourselves and others (Wilson & Golonka, 2013). Conversely, mentalising presents that taking on the perspective of another person is a form of mind-reading, wherein you form a mental representation of the 'other' and use that to inform your perspective judgement (Apperly, 2010). Your perspective is kept separate to that of the other person, though it is still used to inform your mind-reading. There are two theorised processes within mentalisation. Implicit mentalising mechanisms are assumed to be automatic, occurring outside of conscious awareness whereas explicit mentalising requires cognitive effort despite having more flexibility as a process (Frith & Frith, 2008). There are several examples in the literature evidencing how social and emotional factors might impact perspective taking abilities. Happiness can impair mental state inferences whereas sadness can facilitate it (Converse, Lin, Keysar, & Epley, 2008). Feeling powerful was associated with a reduced tendency to comprehend how other people see, think, and feel (Galinsky, Magee, Inesi, & Gruenfeld, 2006). Research into how social and interpersonal factors, including coordination and agency, can impact mental representations of self and other is a topic of interest within the literature. However, the research questions remain too broad to consider the particular influence that can be enacted on specific cognitive processes during social interactions.

1.8 Visual Perspective Taking

Arguably the core element of perspective taking, and ToM overall, is the ability to differentiate what you can see, from what someone else can see. This is visual perspective taking (VPT), a vital skill for communication and survival, which is why the capacity to consider altercentric viewpoints begins at a young age then develops over time. Flavell (1981) defined two levels of VPT: Level-1 is the ability to understand that other people have a different line of sight to ourselves and Level-2, which is the recognition that two people viewing the

same item from different points in space may observe different things. Levels 1 and 2 develop in succession in early infancy, as younger children tend to make more egocentric errors (Epley, Morewedge, & Keysar, 2004). As we get older, we are better able to ascertain differences between what we can see and what others can see. However, research has found that various factors can interfere. Participants with schizophrenia are less likely to spontaneously process the visual perspectives of a social or non-social 'other' (Kronbichler, et al., 2019). Feelings of anxiety or experiencing greater cognitive load can inhibit VPT performance (Todd & Simpson, 2016; Qureshi, Apperly, & Samson, 2010). VPT is key to understanding the minds of others, as being able to judge meaning, attention and knowledge allows for coordination and successful social interactions. However, there is a lack of understanding on how forms of interpersonal coordination, such as synchrony, can impact how we judge between 'self' and 'other' perspective judgements.

There is substantial debate as to whether VPT is an implicit or explicit cognitive mechanism. Wheatley, Kang, Parkinson, and Looser (2012) notes VPT to be a cognitively taxing process due to the requirement of suppressing our own viewpoint to mentalize someone else's. However, Samson, Apperly, Braithwaite, Andrews, and Bodley Scott (2010) ran three VPT experiments and found evidence that taking on someone else's perspective is an implicit, spontaneous process. The experimental design featured the participants being shown a virtual human avatar in the centre of a virtual room, facing either right or left. On the walls some red discs were displayed. In half of the trials the avatars position meant they could not see some of the discs (inconsistent trials), in half the avatar could see the same number of discs as the participant (consistent trials). They found that participants could not ignore the other person's perspective, even when given opportunity to or only required to judge from their own perspective. Participants reacted more slowly and with less accuracy in the inconsistent trials. This effect appears both in judgements from the confederate's perspective (egocentric intrusions) and their own perspective (altercentric intrusions). This result has since become well-established in the literature and the 'dot perspective task' design has been solidified a test to investigate VPT abilities in various contexts.

In the published literature, almost every paper which has used the dot perspective task has modified it in some way, further contributing to the debates surrounding whether the task is measuring mentalising, directional orienting or some combination of the two (Santiesteban, Catmur, Hopkins, Bird, & Heyes, 2014; Pesimena & Soranzo, 2023; Capozzi, Cavallo, Furlanetto, & Becchio, 2014; Cole, Atkinson, Le, & Smith, 2016). Even simply referring to

the process as automatic rather than spontaneous, is something the original paper notes that they deliberately did not confer to the process, as it is difficult to establish automaticity using the experimental task design. O'Grady, Scott-Phillips, Lavelle and Smith (2020) compared subtle differences in methodology to attempt to settle some of the divides across the literature surrounding this task. Ultimately, O'Grady et al., (2020) concluded that participants do *spontaneously* compute the visual perspectives of others and do so without conscious intention although unconscious prompts to attend, but that it is not an automatic response. This allows for utilisation of the dot perspective task as a mechanism to investigate how interpersonal coordination can impact VPT. Whether the task measures attentional orienting, mentalisation or some combination is irrelevant to determining whether our social and cognitive perceptions of the target will impact VPT performance.

Most research utilising the dot perspective task to investigate Level-1 VPT focuses on factors about the observer. However, there is some research about how social factors of the perspective taking target will impact VPT. It had previously been found that the 'uncanny valley' did not impact VPT, as eeriness of the avatar did not impact the intrusion effects (MacDorman & Preethi Srinivas, 2013). Simpson and Todd (2017) explored how group membership could affect perspective taking, even if that group membership was arbitrary and manipulated such as university mascots. It has previously been found that even subtle cues of group membership led to preferential treatment of group members (Hewstone, Rubin, & Willis, 2002). The findings of Simpson and Todd (2017) indicated that egocentric intrusions were stronger when responding for an ingroup avatar. That is, people typically rely on their own self-knowledge when trying to reason between ingroup and outgroup. Having more connection with the ingroup members meant more interference from their own perspective. Further, they did not find any significant effects of avatar group membership on altercentric intrusions. So, the automatic processing of the avatar's perspective was comparable across the groups.

There has been some limited research on how higher order social cognitions can impact VPT. One example is Mattan, Rotshtein and Quinn (2016) who used a modified version of the dot perspective task to investigate the impact of empathy on Level-1 VPT. In this version, the participant engaged in VPT from a third-person view, both the 'self' and the 'other' were presented as virtual avatars in the virtual room. They found that the self-reported measures of empathy reflected improved performance and reduction in intrusion effects, suggesting that being more empathetic makes an individual more flexible in perspective taking judgements.

This evidences that feelings and perceptions of the perspective taking target or 'other' can impact our abilities to take on their visual experience and distinguish it from our own.

Bukowski and Samson (2015) gives another example of higher social cognitions on VPT. They investigated how emotions might impact Level- 1 VPT using a modified version of the dot perspective task. This version induced an emotion from the participant towards a confederate, who became the VPT target in the virtual dot perspective task room, in a pseudo-interactive online card game. Participants were told that their score would determine the earnings of the confederate and vice versa. In the anger condition, the participant believed the confederate had chosen to keep all the earnings whereas in the guilt condition the participant believed that they had done poorly and so didn't earn the confederate much, but the confederate had earned them a considerable amount. This investigation found guilt made participants prioritise the 'other' perspective, whereas anger tended to make them more egocentric. They then ran a second experiment where participants were filmed performing poorly in one condition (shame) or well (control) in another which was ostensibly to show the confederate, as they were shown a video of the confederate performing well (shame) or poorly (control). Here they found that shame caused most interference effects in inconsistent trials. Bukowski and Samson (2015) provided the first evidence that emotions impact Level-1 VPT but also provide support of higher social cognitions having influence. Additionally, the study shows that real confederates can be used as perspective taking targets which opens possibilities for research into VPT and social interactions.

1.9 Thesis Outline

There are two main aims of this research. The first aim is to further investigate how interpersonal synchrony can influence cognitive processing. The second aim is to expand the literature around visual perspective taking, specifically the 'dot perspective task', by introducing prior experience with the perspective-taking target (avatar). Chapter 2 of this investigation explores if and how a synchronous or asynchronous interaction with a confederate will influence performance on the visual perspective taking task (Studies 1 and 2). Further, introducing a Control condition as a comparison to the effects of synchrony and asynchrony (Study 3). Chapter 3 of this investigation examines how the social information of physical cues and informed perception of similarity with the perspective taking target will influence VPT in isolation (Studies 4 and 5). Additionally, how informed perception of similarity and interpersonal coordination will influence VPT as a combination of social information (Studies

6 and 7). Finally, Chapter 3 investigates how predictability of the perspective taking target will influence VPT both within synchrony and asynchronous forms of interpersonal coordination (Studies 8 and 9).

Chapter 2
Synchrony and Visual Perspective Taking:
The Partner Studies

2.1. Introduction

2.1.1. Synchrony

Interpersonal coordination utilises the fact that our brains are constantly making predictions of the approximate future to align our behaviour to match or complement the behaviours of others (Frith & Frith, 2006). We predict what the other person is like and likely to do next based on all the social information, memory and behavioural cues at our disposal and use that prediction to inform what we ourselves will do next. Our ability to predict and act is so exceptional that it can occur with a rapidity which manifests in interpersonal synchrony. This form of synchrony has been found to result in many positive social and emotional outcomes including increased trust and self-esteem, making it beneficial and something that we would want to engage in (Valdesolo, Ouyang, & DeSteno, 2010; Miles, Nind, & Macrae, 2009; Lumsden, Miles, & Macrae, 2014). Unintentional synchrony can often occur when there are clearly defined social norms and naturally emerge from feelings of successful fluid interactions, one example being applause, where audience members naturally synchronise hand clapping (Néda, Ravasz, Brechet, Vicsek, & Barabási, 2000). It is possible to engage in synchrony consciously and intentionally and this has been used frequently throughout history, the Māori Haka for example (Zimmermann & Richardson, 2016).

In theory, there are many options for methods that could be used to investigate the impact of synchrony on social cognition. Studies investigating synchrony have been able to find outcome effects by explicitly instructing participants to engage in synchrony. Valdesolo, Ouyang and DeSteno (2010) had participants rock in rocking chairs synchronously, or asynchronously (and back to back to reduce unintentional synchrony) and Wiltermuth and Heath (2009), had participants walking in synchrony. However, due to the COVID-19 lockdown measures, initial investigations reported in this chapter had to be conducted online, Study 3 was conducted in laboratory settings once restrictions were lifted in order to evaluate methodology effectiveness.

When considering the limitations of an online format for engagement in motor synchrony, the literature surrounding other definitions of synchrony was considered. Research methods employed in testing physiological synchrony of biological rhythms such as hormones, heart rate and neural function, did not yield any suitable methods (Kinreich, Djalovski, Kraus, Louzoun, & Feldman, 2017; Saxbe, et al., 2017; Danyluck & Page-Gould, 2019). However, methodologies used for sensorimotor synchrony (SMS) research provided potential

approaches. Questions surrounding peoples' abilities to flexibly synchronise motor output with sensory input, SMS, is an expanding topic of research in neuroscience (Iversen & Balasubramaniam, 2016). SMS development studies often employ a simple finger-tapping paradigm. Tapping along to an auditory rhythmic cue, which might come from a metronome or musical piece. Such tasks are valuable for investigating rhythmic timing ability and demonstrating fusion of auditory and motor skills and have been used to investigate disorders where there are thought to be impairments of internal timing mechanisms such as ADHD and even vocal stutters (Rubia, Taylor, Taylor, & Sergeant, 1999; Falk, Müller, & Dalla Bella, 2015). Cohen, Abargil, Ahissar and Atzil (2024) recently included a non-social finger-tapping SMS task in addition to a social synchrony task where a pair were observed which highlights that commonality between the mechanisms of social and non-social synchrony are still uncertain (Tunçgenç, Cohen, & Fawcett, 2015).

Both neuroscientific and music research has shown that tapping is within the motor capabilities of most adults (Repp & Su, 2013). Furthermore, this ability has been found to stabilise from young adulthood until old age (Drewing, Aschersleben, & Li, 2006). These tasks are primarily non-social as the participants are synchronizing to stimuli e.g. a metronome. However, a non-social task can become social with the addition/presence of another person (Konvalinka, Vuust, Roepstorff, & Frith, 2010). This thesis seeks to explore if and how synchrony impacts social cognition. Within the constraints of online research, this investigation must ensure both that the participants had either engaged with synchrony or failed to (asynchrony) and that the participant perceives this coordination to be social by using a modification of the SMS tapping task.

2.1.2. Visual Perspective Taking

Visual perspective taking (VPT) was selected as the social cognitive mechanism to investigate the impact of synchrony. VPT is used to cognitively separate one's own visual experience (self) from that of another (other), and to facilitate the bridging of the two different perspectives when needed for processing. A further aim of this investigation is to extend the literature into VPT by considering prior social knowledge of the perspective taking target.

The most well-known and oft-cited measure of the Level-1 VPT literature is the 'Dot Perspective Task', which was first published by Samson et al., (2010) to investigate the concept of spontaneous VPT, in which Level-1 perspectives may be processed efficiently and automatically, outside of cognitive control. This task was chosen due to the accessibility and

easily modified experimental design. The task shows participants pictures of a human avatar facing either right or left and discs pinned on either side. Crucially all discs are always visible to the participant but are not always visible to the avatar. Samson et al., (2010) found that when participants were asked to verify the number of discs that they could see from their own point of view, they were slower and less accurate if the number of discs they could see was different to the number the avatar could see. This finding became known as the 'inconsistency effect' and is suggested to illustrate that participants automatically process the 'other' perspective even when it is not relevant, 'mentalising' what the other person is seeing. This account is further supported by the presence of altercentric intrusions, with participants being slower to respond from their own perspective when the avatars perspective differs from their own (Cole, Atkinson, Le, & Smith, 2016; Surtees & Apperly, 2012). This explanation is contrasted by research into gaze-cueing paradigms, where participants have been found to be faster at identifying objects when the object appears in a socially cued gaze direction and the paradigm is instead attributed to 'attentional cueing' (Driver, et al., 1999; Langton & Bruce, 1999). The gaze cue is argued to cause an attentional shift in the participant, a non-mentalising process. The difference in cognitive attributions between these two areas of research have created some debate over whether the 'dot perspective task' does measure spontaneous VPT mechanisms or if instead it measures attentional orienting processes. There have been variations of the 'dot perspective task' where the avatar has been replaced with a non-social but directional cue, which implies that the mentalising explanation account is insufficient (Santiesteban, Catmur, Hopkins, Bird, & Heyes, 2014; Nielsen, Slade, Levy, & Holmes, 2015).

There has been a decade of strong debate in the literature over whether orienting behaviour is down to attentional processes or mentalising. The debate around the 'dot perspective task' and VPT in general has meant that a lot of the research conducted since 2010 has focused primarily non-human avatars and occulusion tasks. However, since the late 2010's, a case for an intergrated viewpoint has emerged. Rather than considering social orienting as due to attentional orienting *or* mentalising, many researchers are arguing that it is a combination. Although the methodological concerns of confounds between direction and perspective must be taken into account (Capozzi & Ristic, 2020). Nielsen, Slade, Levy, & Holmes (2015) argue that arrows also include some social features and should be considered as semi-social cues. But also that any social cues of arrows are secondary to the directional cues. This is the reverse of human avatars. Pesimena and Soranzo (2023) used a dragon as the avatar in a modifed 'dot perspective task', where the social cue (dragon head) was in the

opposite direction of the nonsocial cue (arrow tail). Their findings supported the integrated account argument. Attentional orienting has been found to occur in response to both social and nonsocial cues. However, when the concept of mental states is included, the magnitude of social orienting responses changes (Capozzi & Ristic, 2018). Baker, Levin and Saylor (2016) determined that versions of the task that explicitly asked for the avatar's perspective measured mentalization rather than directional orienting. All arrows are directional cues, but people differ in how much we follow their gaze. Also, effects of perspective taking are influenced by the context given within the experiment.

There also appears to be an age bias when it comes to social perception tasks. Many studies have found enhanced performance when the target person is of the same age group to the perceiver (Slessor, Phillips, Ruffman, Bailey, & Insch, 2013; Slessor, Laird, Phillips, Bull, & Filippou, 2010; Bailey, et al., 2014). This is further supported by Ferguson, Brunsdon and Bradford (2018) who ran the 'dot perspective task' wherein the age of the avatar was manipulated. They found that altercentric intrusions were reduced or eliminated with an unfamiliar child avatar. This could be explained by own age biases, possibly enhanced visual processing for same age targets or assumptions regarding cognitive capabilities in younger children. To take advantage of the possibility for the former, this Chapter will focus on a specific age range for both participants and confederates.

2.1.3. Social Cognition and VPT

There is a general lack of research that utilises the 'dot perspective task' to investigate social cognitive factors which may affect visual perspective taking. Mattan, Rotshtein and Quinn (2016) examined how VPT performance could be impacted by empathy, arguing that cognitive empathy involves being able to mentally represent and flexibly shift between perspectives of self and other. They found that self-reported measures of empathy were associated with improved VPT performance and reduced perspective interference costs. Thus supporting the view that VPT is affected by social skills. The ability to engage in synchrony could be argued to be a social skill as it has been used throughout history to facilitate group cohesion and prosocial behaviour. Motor synchrony specifically uses joint action to produce a shared goal e.g. dancing together as joint action can create a conceptual 'common ground' between perspectives, bridging the 'self' perspective with the 'other' perspective (Sebanz, Bekkering, & Knoblich, 2006). Following this logic, it could be expected that interpersonal motor synchrony- which has been ensured to occur online by also utlising SMS synchrony-

would result in greater interference effects in perspective judgements, due to 'self' and 'other' perspectives being conceptually linked rather than separated but switchable as with empathy.

Information of the self is processed more efficiently than perspectives of the other (Mattan, Quinn, Apperly, Sui, & Rotshtein, 2014). But handling conflicting perspectives is dependent on cognitive control abilities (Fizke, Barthel, Peters, & Rakoczy, 2014). It is notable that most research using the 'dot perspective task' investigate their questions using virtual, computer generated human avatars (Valerjev & Dujmović, 2017; Drayton, Santos, & Baskin-Sommers, 2018). However, Bukowski and Samson (2015) used a confederate for the avatar to investigate the effect of emotions on VPT. Participants first played a card game with the confederate designed to incite either anger or guilt towards them before performing the 'dot perspective task' with the confederate acting as the avatar. This example is the closest that has been found in the literature to prior knowledge of the confederate. It provides the first evidence of emotions affecting the basic form of perspective taking that is Level-1 VPT. In doing so, it highlights the lack of research into how higher social cognition can impact Level-1 VPT and solidifies the research questions for this Chapter.

2.1.4. Research questions and hypotheses

In two experiments and a pilot study, the hypothesis was investigated that synchronous motor coordination would influence an interactants visual perspective taking of the other interactant. Participants had a synchronous or asynchronous interaction with a confederate who then became the avatar in a modification of the 'dot perspective task'. These confederates were real people, and the 'dot perspective task' used photographs of them in a real room, rather than a 3D avatar in a 3D space. Thus, emphasising the social factors for the online experiment. It was anticipated that the Samson et. al., (2010) inconsistency effects, that when the participant could see a different number of discs to the confederate avatar, they would be slower and less accurate in their responses, would be replicated.

Further, it was hypothesised that having prior social knowledge of the confederate who became the avatar would result in interference effects within the self and other perspective judgements. Finally, it was hypothesised that these interference effects would be stronger following a synchronous interaction with the confederate, compared to a failure to synchronise. If proven, this would provide support for the theory that synchrony impacts cognitive mechanisms as well as social and emotional factors. It would also expand the literature on the

‘dot perspective task’ by considering the prior social knowledge of the target. Details of the experiments are expanded on below.

2.2. Pilot Study

2.2.1. Methodology

Overview

A pilot study was run online between March and May 2021 using E-Prime Go (Psychology Software Tools, 2020). The pilot served primarily as a test of the methodology, establishing whether an instance of interpersonal synchrony (or asynchrony) would be effective if conducted online.

Participants

Participants were gathered through advertisements posted on Facebook and Instagram and the University of East Anglia's SONA system. In total, there were 53 participants, aged 18-40, 45 were right-handed, 36 identified as female. No exclusion criteria were applied, so analysis included all participants data.

Stimuli and Design

The study used a 2x2x2 mixed design, with participants assigned to one of two Coordination conditions: Synchrony (N = 24) or Asynchrony (N=29). There were two within-subjects factors manipulated within the VPT task: Perspective (Self vs Other) and Consistency (Consistent vs Inconsistent). The dependent variables were accuracy and reaction times (RT).

Figure 1: Example of the confederate used in the visual perspective task of the pilot study

Materials and Procedure

Participants were provided instructions and were debriefed via a video conference with the researcher. The hyperlink to the experiment was provided immediately following

instruction. The first task of the experiment was the Coordination task. Participants were presented with one of two videos, depending on which Coordination group they had been assigned to. All participants saw the same confederate and in all conditions the participants were instructed to tap their hand on the flat table in front of them to the beat of the music that they could hear while watching the video they were shown. The music continued for the duration of the video.

The next task was the VPT task, a modified version of the Samson et al., (2010) version. The only modification being that the 'avatar' was the confederate from the Coordination task, photographed in a real room. The stimuli presented were images of the confederate in profile, centred in the frame against a blank wall (see Figure 1). In front of and behind the confederate were between 0 and 3 grey discs, at the confederate's eye level. The number of discs were changed for each trial. In 50% of trials, the confederate could see the same number of discs as the participant (Consistent) and in the other 50%, the participant could see all of the discs, but the confederate could not, due to the direction in which they were facing (Inconsistent).

Each trial began by presenting a fixation cross for 1 second, then a blank screen for 500 milliseconds (ms). The participant was then informed whether they would be judging from their own perspective (Own) or the confederate's perspective (Other) respectively. This was done by display of a perspective cue of either "YOU" or "HE/SHE" (depending on gender of confederate). This was followed by another blank screen for 500 ms, then the second cue given was for the number of discs (0-3). Only then was the image of the confederate and discs for that trial shown. Participants had 2000 ms to respond to the trial image on screen before the trial timed out and returned to the fixation cross for the next trial. For their response, participants were given prior instructions to verify whether or not the two cues matched the image they were shown with keyboard responses; pressing the keys M ('yes') if they matched or Z ('no') if the cues were mismatched. For example, if the prompt was the confederate's perspective and 3 discs, and the image showed the confederate had 2 discs in front of them and 1 disc behind and the correct response would be 'no' (an inconsistent, mismatching trial).

Analysis Protocol

No data was recorded from the Coordination task. In the experimental trials for the VPT task, there were 96 matching ("yes") trials comprising; 48 trials where participants were asked to confirm their own perspective (with 24 Consistent and 24 Inconsistent perspective trials) and 48 trials where participants were asked to confirm the confederate's perspective (with 24

Consistent and 24 Inconsistent perspective trials). There was an equal number of mismatching ("no") trials to matching trials and an additional 16 filler trials, in which there were no discs in the image at all. The filler trials had an equal number of Own and Other, Consistent and Inconsistent, matching and mismatching trials. The order of trials within a block was randomized and counterbalanced across participants.

For matching of Consistent and Inconsistent trials, the number cue was matched to the number of discs seen from the perspective cue ("YOU" or "HE/SHE"). On mismatching Inconsistent trials, the number cue corresponded with the number of discs from the non-cued perspective (e.g. Other when the cue was "YOU"). For mismatching Consistent trials, the number cue did not match the discs in the confederate or participants perspective. These trials were therefore much easier to process than any other trials but were included for balance. Subsequently any mismatching trials (where the correct answer was 'no' or 'Z') were treated as filler and only the matching 'yes' trials were included in analyses.

2.2.2. Results

Accuracy

Accuracy was calculated for each cell of the 'Perspective x Consistency' design. Scores were analysed with a three-way mixed model Analysis of Variance (ANOVA) where Perspective and Consistency were within subjects' variables and Coordination was a between-subjects factor (see Table 1). There was only a significant Consistency effect $F(1, 51) = 25.16$, $p = .001$, $\eta_p^2 = .33$. Participants were more accurate on Consistent trials (M = .97, SD = 0.08) than Inconsistent trials (M = .89, SD = 0.10).

No other significant effects were found. The effect of Perspective was not significant $F(1, 51) = 0.28$, $p = .60$, $\eta_p^2 = .01$. The two-way interactions were also not significant, Perspective x Consistency $F(1, 51) = 0.32$, $p = .58$, $\eta_p^2 = .01$, Perspective x Coordination $F(1, 51) = .87$, $p = .36$, $\eta_p^2 = .012$, Consistency x Coordination $F(1, 51) = 0.70$, $p = .41$, $\eta_p^2 = .02$. The three-way interaction of Perspective x Consistency x Coordination was also not significant $F(1, 51) = 0.01$, $p = .93$, $\eta_p^2 = .00$.

Table 1: Means (and Standard Deviations) for Accuracy in the pilot.

	Synchrony	Asynchrony
Own Consistent	.95 (*.19*)	.99 (*.03*)
Own Inconsistent	.90 (*.12*)	.91 (*.09*)
Other Consistent	.96 (*.07*)	.97 (*.04*)
Other Inconsistent	.80 (*.15*)	.88 (*.12*)

Reaction Times

Mean reaction time was calculated separately for each cell of the Perspective x Consistency design, and the means were analysed with a three-way mixed model ANOVA where Perspective and Consistency were repeated measures and Coordination was a between-subjects factor (see Table 2). There was a significant effect of Consistency $F(1, 51) = 57.90$, $p = .001$, $\eta_p^2 = .53$. Participants were faster to respond accurately on consistent trials (M = 736.87, SD = 160.87) than inconsistent trials (M = 823.45, SD = 181.76). The differences in Consistency effects between conditions for reaction time are displayed in Figure 2.

Table 2: Means (and Standard Deviations) for Reaction Times in the pilot.

	Synchrony (*ms*)	Asynchrony (*ms*)
Own Consistent	797 (*177*)	713 (*163*)
Own Inconsistent	817 (*179*)	806 (*205*)
Other Consistent	738 (*180*)	699 (*148*)
Other Inconsistent	857 (*172*)	813 (*202*)

There was also a significant Perspective x Consistency interaction effect $F(1, 51) = 9.787$, $p = .003$, $\eta_p^2 = 161$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(52) = -4.15$, $p < .001$, $d = 0.61$, with a 59ms advantage in the consistent condition and a numerically larger Consistency effect when participants were judging from the confederates perspective $t(146) = -8.54$, $p < .001$, $d = 1.12$, with a 117ms advantage in the consistent condition.

No further two-way interactions were significant, Perspective x Coordination $F(1, 51) = 0.07$, $p = .79$, $\eta_p^2 = .00$, Consistency x Coordination $F(1, 51) = 2.21$, $p = .14$, $\eta p^2 = .04$. Additionally, there was no significant Perspective x Consistency x Coordination interaction effect $F(1, 51) = 4.098$, $p = .048$, $\eta_p^2 = 07$.

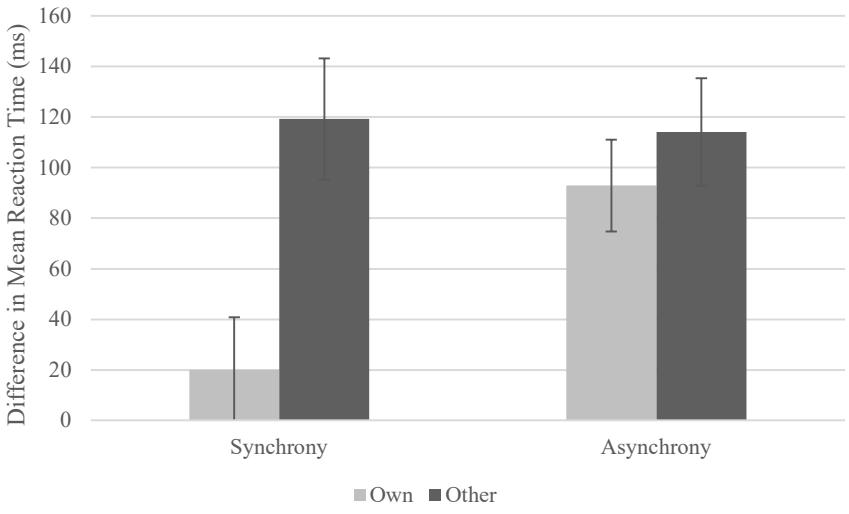


Figure 2: Reaction time Consistency effects within each Perspective condition for the two Coordination conditions in the pilot study

2.2.3. Discussion

The aim of the pilot study was to test the experimental method. From the findings, it can be concluded that the method chosen was effective for conducting an online investigation into the question of how synchrony can influence visual perspective taking performance. Additionally, that the choice of analysis was suitable for the investigation. Dialogue with participants during video conferencing to instruct the participant prior to the experiment and debrief at the end provided valuable anecdotal evidence. This led to the addition of questionnaires before conclusion of the experiment about perceptions of, and feelings towards the confederate. However, it was determined that video conferencing was not necessary and could be sufficiently replaced with text in the experiment itself. The programme used to design and host the experiment was changed following the pilot study, to one better suited at the time for online data collection. Further, different confederates and subsequently stimuli would be used in future studies as they could be gender matched to the participants and the age limit was also brought down from 18-40 to 18-30 to reduce possible biases.

The findings of the pilot study provide evidence that interpersonal coordination influences visual perspective taking. However, due to the lack of power, the effect is not conclusive. But does provide an excellent foundation to pursue the area further with expansion and replication. Evidence was found of interference in the inconsistency effects showing that prior social information of the confederate did impact the participants ability to take on their visual perspective in the modified ‘dot perspective task’. Further, a difference in interference is observed based on whether the participants synchronised or failed to synchronise (asynchrony) with the confederate. Again, the effects are not conclusive but act as justification to pursue this research.

2.3. Study 1

2.3.1. Methodology

Overview

Study 1 tests the hypothesis that a prior synchronised coordinated interaction with a partner will affect one's ability to spontaneously take on the perspective of the same partner. Consistent with Samson et al., (2010), it was first necessary to show that there was an effect of consistency wherein participants would be faster and more accurate when making visual judgments, in cases where the number of objects that could be seen from their own and their partner's perspectives were the same. The hypothesis was that these effects would be qualified by participants' prior experience with their partner – specifically, whether they had previously engaged in synchronous or asynchronous coordination with them.

Following the results of the pilot study, it was expected that synchrony would result in greater interference. That is, following a synchronous interaction, it was expected that participants to find it more difficult to ignore their partner's perspective when making self-perspective judgments and more difficult to ignore their own perspective when making partner-perspective judgments. This research received general ethical approval on 19-01-2021 from the Ethics Board of the University of East Anglia (UEA).

Participants

A power analysis carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) indicated that to detect a medium effect size, d=0.5, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 128 would be required for an independent samples t-test. This effect size for the interaction with coordination had been determined from the pilot study and an undergraduate project from 2019 (supervised by N.A. Wyer). Participants were only able to complete the study if they were aged between 18 and 30, those older or younger were automatically rejected. Participants were excluded if they responded to the final experimental question of 'Did you actually tap your hand to the beat of the music you heard?" with response 3 ("Not at all"). Participants were also excluded from the analysis if they were less than 67% accurate in any of the four trial conditions. The VPT task was straightforward, this exclusion criteria was applied to ascertain if the participants had engaged with the experiment and been able to follow instructions. Accuracy of less than 67% could be due to random chance. Therefore, results from participants with an accuracy of <67% were excluded.

In total, 299 participants completed the experiment but following the above exclusion criteria, only the data from 147 participants were used in analyses. It is theorised that the notable reduction in participant numbers following these exclusion criteria is due to the online nature of the study. Data collection ran between November 2021 and March 2022, with participants recruited through SONA systems at the University of East Anglia. All participants were undergraduate Psychology students and were compensated with course credits.

Participants were assigned into one of two 'Coordination' groups. A programme error meant that participants were not assigned randomly. There were 73 participants in the 'Synchronous Group' (*Mage*=19.79, *SD* =1.80, 63 identified as female, 65 were right-handed). The 'Asynchronous Group' had 74 participants (*Mage*=19.82, *SD* =2.41, 63 identified as female, 64 were right-handed).

Design and Materials

The investigation used a mixed design. The between-subjects factor of this Study was Coordination; Synchrony or Asynchrony. There were two within-subjects factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Own and Other.

Four videos were prepared for use in the Coordination task. One male and one female confederate, both in their early-mid 20s, were asked to listen to a piece of music and tap their hands in time to the beat as illustrated in Figure 3. Both completed this procedure for two pieces of music, each lasting approximately 3 minutes. The background of the videos was standardised to be a neutral laboratory setting and both individuals were dressed in similarly indistinct casual clothes. In the 'Asynchrony' video the individual was shown tapping at a visibly slower bpm than the audio track that the participants could hear. The 'Synchrony' video showed the individual tapping at the same speed as the audio track the participant could hear. As all participants would only see one video, the same 100bpm audio track was used for all four. Additionally, the tapping of the individual being recorded was not audible so the participant wouldn't be able to synchronize to that auditory cue instead of the music.

For the VPT task, 22 images each were prepared of both the individuals that were recorded for the Coordination task. The individuals were depicted standing in profile with differing numbers of discs on either side of them (11 facing right, 11 facing left). Figure 4 illustrates the image for an inconsistent trial with the female confederate.

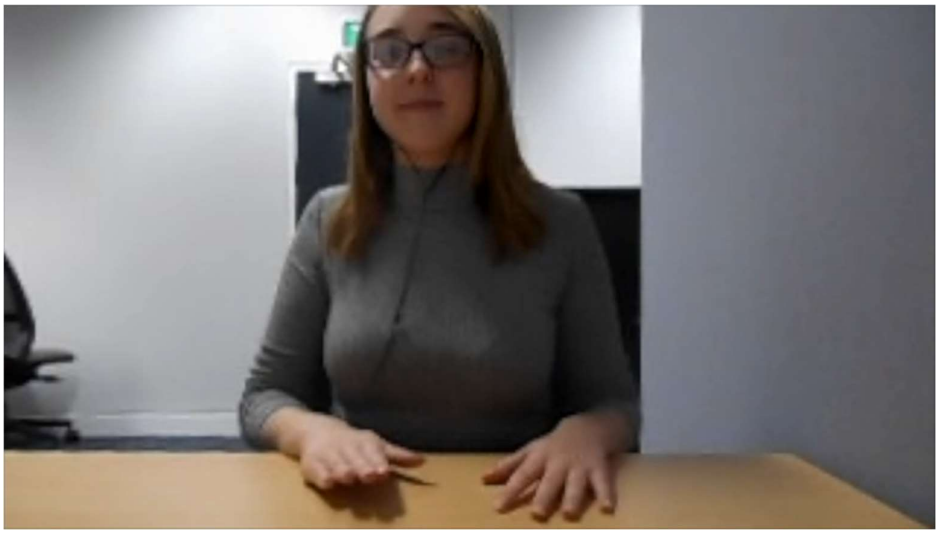


Figure 3: Screenshot from one of the coordination task videos of the female confederate tapping in Study 1

Figure 4: Image of the female confederate used for an inconsistent trial in the visual perspective task in Study 1

Spontaneous visual perspective taking was measured by a modified visual perspective-taking (VPT) task developed by Samson et al., (2010) as described in Section 2.2.1. The confederate from the coordination task acted as the perspective taking target in the VPT task. The dependent variables measured were percentage of correct responses (Accuracy) and speed

of correct responses (Reaction Times). Following the experimental tasks, all participants were asked to complete three questionnaires and a similarity rating to investigate their perceptions of their 'interaction partner' and assess outcomes related to perspective taking. Pronouns were adjusted depending on confederate gender. The Gorilla Experiment Builder (www.gorilla.sc) was used to create and host the experiment.

Additional Measures[1]

All participants completed the Mind Attribution Scale (Kozak, Marsh, & Wegner, 2006), a 10-item questionnaire designed to assess the extent to which participants viewed their partner as having independent mental states. Items such as 'is capable of planned action' were rated from 1 ('Strongly Disagree') to 5 ('Strongly Agree').

All participants completed a 10-item Trust Scale which included 5 items taken from the Trust in Close Relationships scale (Remple, Holmes & Zanna, 1985). 3 items were from the General Trust scale (Yamagishi & Yamagishi, 1994), 1 item taken from an earlier version (Yamagishi, 1986), and 1 item from the Trust in People Scale (Michigan election Study, 1964). The compilation Trust Scale was piloted prior to this investigation and found to be sensitive to Coordination manipulations.

Thirdly, the Empathy Quotient (Baron-Cohen & Wheelwright, 2004). All participants completed a 21-item questionnaire, which was adapted to refer specifically to participants' 'interaction partner'. This questionnaire measures how empathetic the participant feels that they could and should be towards the confederate and how well the confederate would recognise their empathy. This questionnaire required the participant to imagine an actual meeting with the confederate as all questions began with the prompt "Imagine that you met the person that you saw. Please indicate how much you agree or disagree with each of the following statements." Example statements included "I would always try to consider her feelings before I do something." and "I would find it difficult to see things from her point of view." Again, participants could rate between 1, labelled as 'Strongly Disagree' and 5, labelled as 'Strongly Agree'. A higher score would indicate the participant assuming greater empathy towards the confederate. The three questionnaires presented their response options on a series of static Likert scales.

[1] Additional Measures questionnaires are located in the Appendices

Finally, ‘Similarity’ was measured using a slider scale that could be moved by participants. One end of the scale read ‘Not at all similar’ and the far end of the scale had ‘Extremely similar’ as the option. The marker that the participants could use was default at ‘Not at all similar’. The resulting location of the marker was turned into a numerical score from 0 to 100.

Procedure

To ensure that all participants had the necessary equipment to enable them to access the audio-visual stimuli in the experiment, participants were first asked to run a short audio test, adapted from a UCL basic task node offered by Gorilla. After this, participants were asked to provide consent and some demographic information to confirm their eligibility to take part in the study.

Eligible participants proceeded to the first task of the experiment. The participants were allocated the confederate whose gender matched their own. Only a male and female confederate had been programmed so any participant who reported themselves to be ‘Non-Binary’, ‘Other’ or ‘Prefer Not to Say’ were shown the female confederate. Participants were presented with one of two videos, depending on which Coordination group they had been assigned to. As in the pilot study, in all conditions the participants were clearly instructed to tap their hand on the flat table in front of them to the beat of the music that they listened to while watching the video that they were shown. Participants were informed that this task would last up to 3 minutes and that they should continue tapping the whole time.

The second task was the VPT task, adapted from Samson et al. (2010). This had the same modifications as the pilot study. Images of the confederate that the participant saw in the coordination task video acted as the avatar. Participants were given two prompts, a perspective and a number cue, before being shown an image. Figure 5 shows the timing of each stage of the task and Figure 6 shows all the combinations.

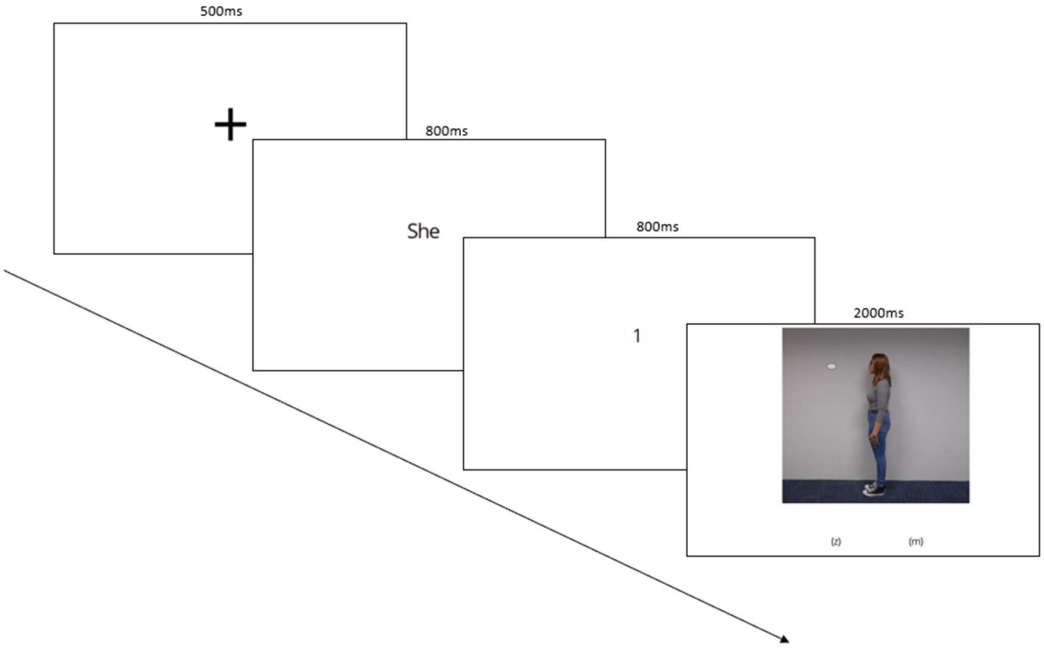


Figure 5: Example of a Consistent Other perspective with timings for Study 1

Prior to commencing the experimental trials, participants undertook 20 practice trials. The data from these trials were recorded but were not included in the analysis. Participants were offered a reminder of the instructions prior to commencement of the recorded experimental trials. Participants were offered a break and a second reminder of the instructions at the exact midpoint of the VPT task. The time taken before the participant resumed the study was recorded but not included in final analysis.

Following the VPT task, participants were informed that they would be asked some questions regarding their own perceptions of the person that they had just seen (the confederate). They were encouraged to answer honestly and assured that their responses would be anonymous and would never be seen by the confederate.

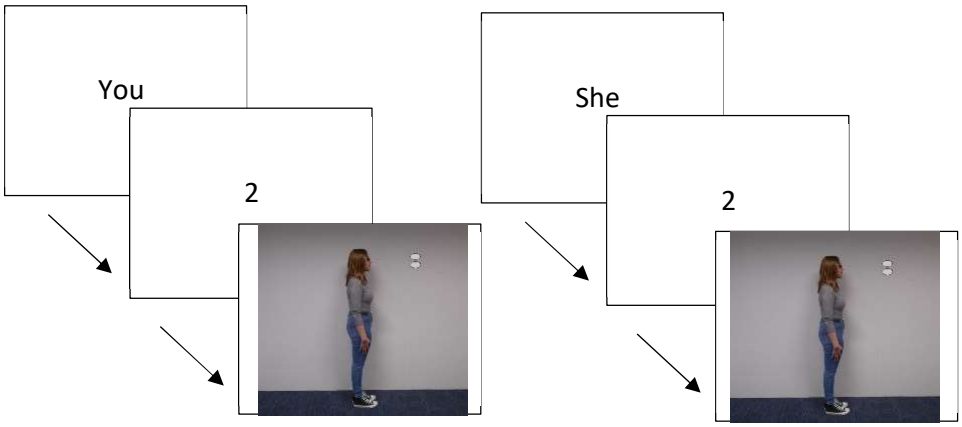
Participants were then presented with the Mind Attribution Scale, Trust Scale and Empathy Quotient questionnaires in immediate succession. Participants were then required to score "How similar did you feel to the person on screen?" by moving an icon along a sliding scale.

The final questions asked participants whether they did, in fact, tap their hand for the whole of the Coordination task. To ensure their honesty, participants were assured that their answer would not affect whether they received compensation. They could answer ‘Yes throughout the whole task’, ‘Only part of the time’, ‘Not at all’. Participants were also asked if, during the coordination task, they believed that the other person was listening to the same music that they were. The answer options were ‘Yes’, ‘No’, ‘I didn't think about it’, ‘I did at first but then changed my mind’.

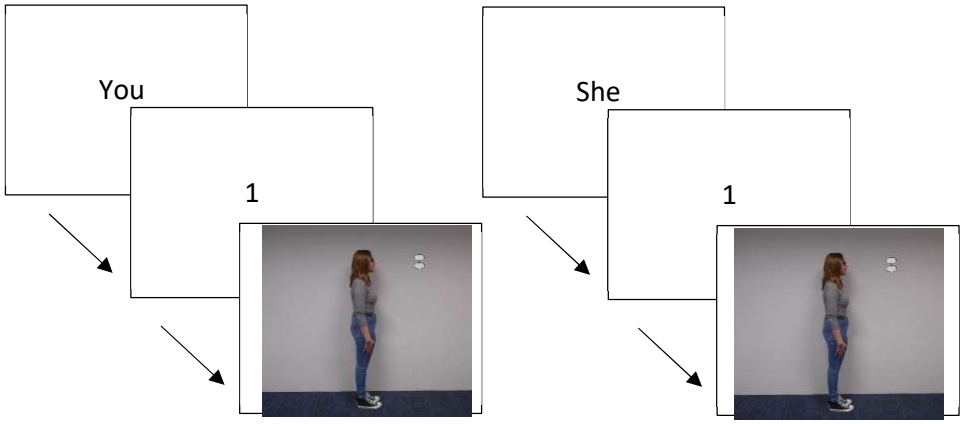
Perspective	Self	Other

Consistent

Matching ("Yes" response)

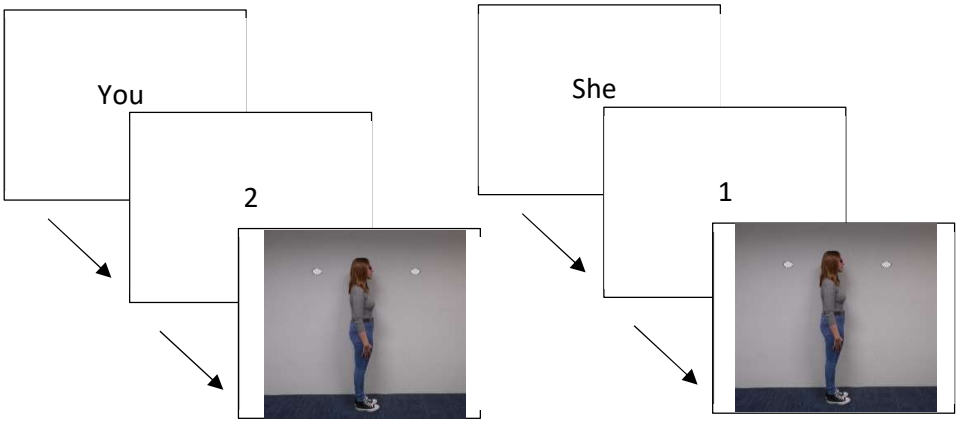


Mismatching ("No" response)

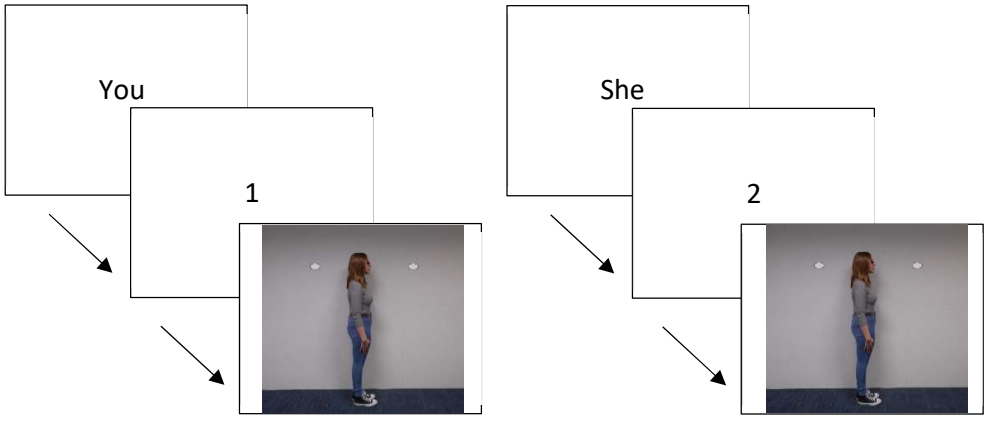


Inconsistent

Matching ("Yes" response)



Mismatching ("No" response)



2.3.2. Results

Analyses

The primary analysis was a 2x2x2 mixed-model analysis of variance (ANOVA) with Perspective (Own or Other) and Consistency (Consistent or Inconsistent) as the within subject variables and Coordination (Synchronous or Asynchronous) as the between subject factor.

For post-hoc analysis the trade-off between accuracy and reaction times were used to calculate the inverse efficiency scores. These provided an index per participant of how long it took to make the correct response and were calculated by dividing the percentage of correct responses by the reaction times. No data was recorded from the coordination task.

Accuracy

Accuracy (i.e. percentage of correct trials) was calculated for each trial condition, based on the Perspective x Consistency design. Trials that were 'timed out', where participants failed to respond within the 2000ms limit, were treated as errors.

Mean accuracy scores were analysed using a three-way mixed model ANOVA (see Table 3). The expected Consistency effect was observed $F(1, 145) = 98.09$, $p < .001$, $\eta_p^2 = .40$. Participants were more accurate when the confederate's perspective was consistent with their own (M = .94, SD = .06) rather than when perspectives were Inconsistent (M = .88, SD = .08). The effect of Perspective was also significant $F(1,145) = 10.56$, $p = .001$, $\eta_p^2 = .07$, participants were more accurate when judging from their own perspective (M = .92, SD = .07) than when judging from the confederate's perspective (M = .90, SD = .07).

Table 3: Means (and Standard Deviations) for Accuracy in Study 1

	Synchrony	Asynchrony
Own Consistent	.95 (*.08*)	.95 (.07)
Own Inconsistent	.89 (*.10*)	.89 (*.10*)
Other Consistent	.93 (*.09*)	.93 (.09)
Other Inconsistent	.87 (*.10*)	.84 (*.10*)

None of the two-way interactions were significant, Perspective x Consistency $F(1, 145) = 2.35$, $p = .13$, $\eta_p^2 = .02$, Perspective x Coordination $F(1, 145) = 0.82$, $p = .37$, $\eta_p^2 = .01$,

Consistency x Coordination $F(1, 145) = 1.32$, $p = .25$, $\eta_p^2 = .01$. The Perspective x Consistency x Coordination interaction was also not significant $F(1, 145) = 0.99$, $p = .32$, $\eta_p^2 = .01$.

Reaction Times

Mean reaction times were analysed in the same way as accuracy (see Table 4). There was a significant Consistency effect for reaction times $F(1,145)= 79.86$, $p < .001$, $\eta_p^2 = .36$. Participants had a slower overall reaction time when both perspectives were Inconsistent (M = 898.56, SD = 172.17) than when both perspectives were Consistent (M = 819.66, SD = 146.07).

Table 4: Means (and Standard Deviations) for Reaction Times in Study 1

	Synchrony (*ms*)	Asynchrony (*ms*)
Own Consistent	826 (*169*)	809 (*165*)
Own Inconsistent	883 (*163*)	834 (*166*)
Other Consistent	852 (*174*)	793 (*157*)
Other Inconsistent	949 (*225*)	928 (*211*)

In addition, there was a significant effect for Perspective $F(1,145)= 17.39$, $p < .001$, $\eta_p^2 = .12$. Participants were faster at responding correctly when asked to judge from their own perspective (M = 837.61, SD = 147.98) than when asked to judge from the confederate's perspective (M = 880.13, SD = 175.42).

There was a significant Perspective x Consistency interaction effect $F(1, 145)= 15.57$, $p < .001$, $\eta_p^2 = .10$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(146)=-3.31$, $p < .001$, $d = 0.60$, with a 40ms advantage in the Consistent condition and a numerically larger Consistency effect with a 116ms advantage in the Consistent condition when participants were judging from the confederates perspective $t(146)= -8.54$, $p < .001$, $d = 0.84$. The differences in Consistency effect for each perspective, grouped by coordination are displayed in Figure 7.

Perspective x Coordination was not significant $F(1, 145) = 0.13$, $p = .72$, $\eta_p^2 < .01$). Neither was Consistency x Coordination $F(1, 145) = 0.03$, $p = .86$, $\eta_p^2 = .01$. The Perspective x Consistency x Coordination interaction was not significant $F(1,145)= 3.43$, $p = .07$, $\eta p^2 = .02$. Split file paired t tests found that in the Asynchronous coordination group there was a nonsignificant Consistency effect when judging from own perspective $t(73)= -1.44$, $p = .08$, d

= 0.17 and a significant Consistency effect in the other perspective $t(73)= -8.35$, $p < .001$, $d = 1.22$. For the Synchronous coordination group there was a significant Consistency effect when judging from the participants own perspective $t(72)= -3.26$, $p < .001$, $d = 0.95$ and a numerically larger one from the other perspective judgements $t(72)= -4.44$, $p < .001$, $d = 0.61$.

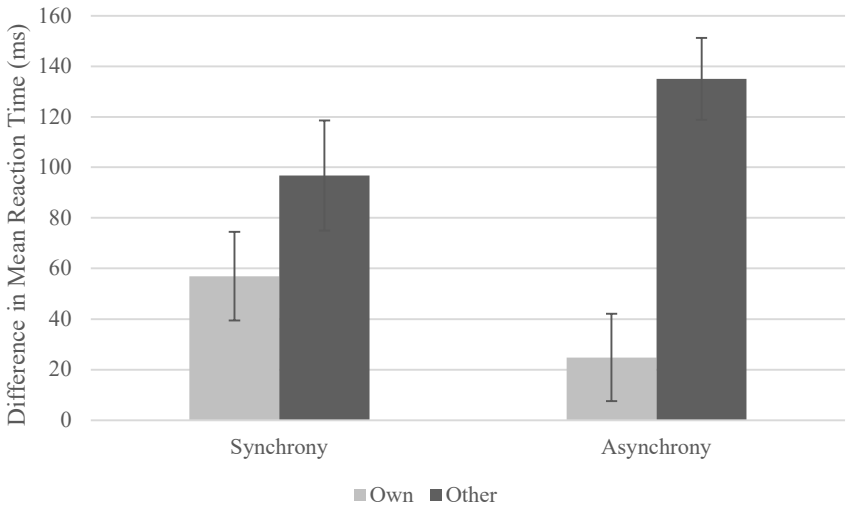


Figure 7: Reaction time Consistency effects within each Perspective condition for the two Coordination conditions in Study 1.

Inverse Efficiency Score

A speed-accuracy trade-off analysis was conducted to consider the participants willingness to respond quickly with the risk of making more errors or respond more slowly to make fewer errors. The inverse efficiency score was determined by dividing reaction times by percentage of correct responses for each participant in each trial type. The inverse efficiency scores were then run through a 3-way ANOVA to test the effect of Coordination, Perspective and Consistency on this speed-accuracy trade-off. Descriptive statistics are displayed in Table 5.

Table 5: Means (and Standard Deviations) for Inverse Efficiency Scores in Study 1

	Synchrony (*ms*)	Asynchrony (*ms*)
Own Consistent	881.29 (214.57)	862.31 (216.12)
Own Inconsistent	1004.63 (233.53)	950.45 (230.05)
Other Consistent	926.16 (237.83)	859.34 (209.64)
Other Inconsistent	1104.96 (310.50)	1121.90 (328.95)

There was a significant Consistency effect $F(1,145)= 149.54$, $p < .001$, $\eta_p^2 = .51$. Participants were much faster to make the correct response when their perspective and the confederate's perspective were Consistent (M = 882.27, SD = 190.87) compared to Inconsistent (M = 1045.49, SD = 240.43).

There was also a significant effect of Perspective $F(1,145)= 24.72$, $p = .001$, $\eta_p^2 = .15$. Participants were much faster to make the correct response when judging from their own perspective (M = 924.67, SD = 201.81) compared to the other perspective (M =1003.09, SD = 242.28).

There was a significant Perspective x Consistency interaction effect $F(1,145)= 17.57$, $p < .001$, $\eta_p^2 = .11$. When judging from their own perspective, participants were slightly faster to reach the correct response when the two perspectives were Consistent (M = 871.80, SD = 215.36) than Inconsistent (M = 977.54, SD = 231.79). However, when judging from the other perspective, participants were much faster to make the correct response when the two perspectives were Consistent (M = 892.75, SD = 224.08) than Inconsistent (M = 1113.43, SD = 319.93). There was also a significant Perspective x Consistency x Coordination interaction effect $F(1,145)= 4.71$, $p = .03$, $\eta_p^2 = .03$.

Additional Measures

Independent samples t-tests were used to investigate the effect of Coordination on ratings of Mind Attribution, Trust, Empathy, and Similarity. The descriptive statistics are shown in Table 6. The sole significant effect was on the self-reported similarity rating. Participants who had a Synchronous interaction with their partner (M = 36.10, SD = 21.22), reported higher ratings of Similarity with the partner than participants who had an Asynchronous interaction (M = 26.55, SD = 23.00); $t(145)= .89$, $p = .01$, $d = -0.43$.

Table 6: Means (and Standard Deviations) for Additional Measures in Study 1

	Synchrony	Asynchrony
Similarity	36.10 (*21.22*)	26.55 (*23.00*)
Mind Attribution	3.88 (*.76*)	3.95 (*.77*)
Trust	3.28 (*.56*)	3.26 (*.49*)
Empathy	3.35 (*.36*)	3.28 (*.46*)

There was no significant difference between Synchronous and Asynchronous groups for perceived Trust of the confederate $t(145)= .31$, $p =.75$, $d= -0.05$. There was also no significant difference from the scores given for the Mind Attribution scale $t(145)= -.53$, $p = .60$, $d = 0.09$ and no significant difference for Empathy $t(145)= 2.61$, $p = .38$, $d= 0.15$.

2.3.3. Discussion

The aim of Study 1 was to investigate if a synchronised motor interaction would influence spontaneous visual perspective taking. The addition of a social context to the avatar was novel to this research. Experiencing motor synchrony with the avatar was anticipated to influence visual perspective taking positively to some degree. Interpersonal synchrony has numerous positive outcomes for social interactions and on the self, such as increased trust, cooperation and self-esteem (Valdesolo, Ouyang, & DeSteno, 2010; Zimmermann & Richardson, 2016; Miles, Nind, & Macrae, 2009). It is also known that synchronising can affect perceptions of strangers and proposed that synchronising with someone will influence immediate subsequent interactions with that person.

The hypothesis was that being synchronous with another person will aid a subjects' ability to take on their perspective. Study 1 provides evidence that synchrony does influence visual perspective taking. Synchrony appears to ease the implicit computation of another's visual experience but makes it more difficult to disregard it when required to focus on own visual experience. The increased altercentric intrusions and reduced egocentric intrusions express both the participant's ease in taking on the confederate's perspective but trouble in separating it from their own. Synchrony has been shown to increase the participants sense of extended-other agency and self-other merging (Reddish, Tong, Jong, & Whitehouse, 2020; Paladino, Mazzurega, Pavani, & Schubert, 2010). The findings reported here suggest that successful synchronous interaction leads to participants bringing their mental representations of 'self' and 'other' closer together. Causing perspective interference and intrusion effects in visual perspective taking.

The results of Study 1 directly oppose the findings of the Pilot Study. The interference effects of synchrony in Study 1 mirror the effects of asynchrony in the Pilot Study. Whilst this difference is likely due to the lack of power in the Pilot Study as well as improved design and more stringent criteria of Study 1 compared to the pilot, a further replication with random assignment of participants is needed to draw more concrete conclusions.

12.4. Study 2

2.4.1. Methodology

Overview

In Study 1, a program issue meant that the participants were not assigned randomly into the Synchronous and Asynchronous condition. This meant that more participants had to be collected than the power analysis indicated, to ensure the groups were of equivalent sizes. This also led to 'Study 2', an exact replication of Study 1 but with randomly assigned participants.

Participants

The experiment was advertised on Prolific and data collection ran in June 2022. A total of 128 participants were recruited, as was indicated by the power analysis for Study 1. However, following application of the same exclusion criteria, the data of only 89 were used in analysis. This sample had been balanced by gender of participant, enabling investigation of any potential differences. The sample was randomly assigned into the 'Coordination' Groups. The 'Synchronous Group' had 41 participants (M*age*=24.88, SD =4.07, 23 identified as female, 39 were right-handed). The 'Asynchronous Group' had 48 participants (M*age*=24.96, SD = 3.51, 26 identified as female, 46 were right-handed).

Design and Materials

The between-subjects' factor of this study was Coordination; Synchrony or Asynchrony. There were two within subject factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other.

Study 2 was an exact replication of Study 1, but with random assignment of participants to Coordination conditions. The stimuli used, gender match of participants to confederates, the additional measures and hosting programme were therefore the same.

Procedure

As Study 2 was an exact replication of Study 1, but with random assignment of participants to Coordination conditions, all procedures were the same as Study 1.

2.4.2. Results

Analyses

The analyses for this experiment matched Study 1 exactly.

Accuracy

A three-way ANOVA was performed to analyse the effect of Similarity (High or Low), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) on accuracy rates. Mean accuracy rates per trial condition are shown in Table 7.

The ANOVA revealed a significant effect of Consistency for accuracy $F(1,87)= 63.60$, $p <.001$, $\eta p^2 = .42$. Participants were more accurate when both perspectives were Consistent ($M =.97$, $SD = .04$) than when both perspectives were Inconsistent ($M =.90$, $SD = .08$).

Table 7: Means (and Standard Deviations) for Accuracy in Study 2

	Synchrony	Asynchrony
Own Consistent	.98 (*.04*)	.98 (*.04*)
Own Inconsistent	.92 (*.11*)	.90 (*.10*)
Other Consistent	.95 (*.07*)	.96 (*.07*)
Other Inconsistent	.89 (*.08*)	.89 (*.11*)

There was a significant effect on accuracy of Perspective $F(1,87)=7.47$, $p=.01$, $\eta p^2 =.08$. Participants were more accurate when judging from their own perspective ($M =.94$, $SD = .06$) than the confederate's perspective ($M =.92$, $SD = .07$).

There were no significant two way interactions for accuracy, Perspective x Consistency $F(1,87)=0.79$, $p = .38$, $\eta p^2 = .01$, Perspective x Coordination $F(1,87)=0.78$, $p = .38$, $\eta p^2 = .01$, Consistency x Coordination $F(1,87)= 0.71$, $p = .40$, $\eta p^2 = .01$. Further, the three-way interaction of Perspective x Consistency x Coordination $F(1,87)= 0.04$, $p = .85$, $\eta p^2 = .00$.

Reaction Times

To determine the effect of Similarity, Perspective, and Consistency on reaction times, a 3-way mixed model ANOVA was conducted. Mean reaction times per trial condition are displayed in Table 8.

Table 8: Means (and Standard Deviations) for Reaction Times in Study 2

	Synchrony (*ms*)	Asynchrony (*ms*)
Own Consistent	726 (*138*)	735 (*163*)
Own Inconsistent	790 (*172*)	798 (*179*)
Other Consistent	737 (*138*)	740 (*166.*)
Other Inconsistent	836 (*141*)	870 (*209*)

There was a significant Consistency effect for reaction times $F(1,87)= 150.06$, $p <.001$, $\eta p^2 =.63$, with both groups having slower overall reaction times when both perspectives were Inconsistent ($M =821.21$, $SD = 167.09$) than when both perspectives were Consistent ($M = 734.40$, $SD = 146.39$).

The main effect of Perspective was also significant $F(1,87)= 14.46$, $p <.001$, $\eta p^2 =.14$. Participants were faster to respond correctly when judging from their own perspective ($M =762.08$, $SD = 157.73$) than the confederate's perspective ($M =793.53$, $SD = 158.99$).

Further there was a significant Perspective x Consistency interaction effect $F(1,87)= 7.89$, $p=.01$, $\eta p^2 =.08$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(89)= -6.40$, $p <.001$, $d =0.84$, with a 64ms advantage in the Consistent condition and a numerically larger Consistency effect when participants were judging from the confederates perspective $t(89)= -9.54$, $p <.001$, $d = 1.13$.

There were no other significant two-way interactions (largest $F(1,87)= .41$, $p=.48$, $\eta p^2 =.00$). Further there was no interaction between Perspective, Consistency and Coordination $F(1,87)= .47$, $p=.50$, $\eta p^2 =.01$. The difference in Consistency effect for each perspective, grouped by Coordination are displayed in Figure 8.

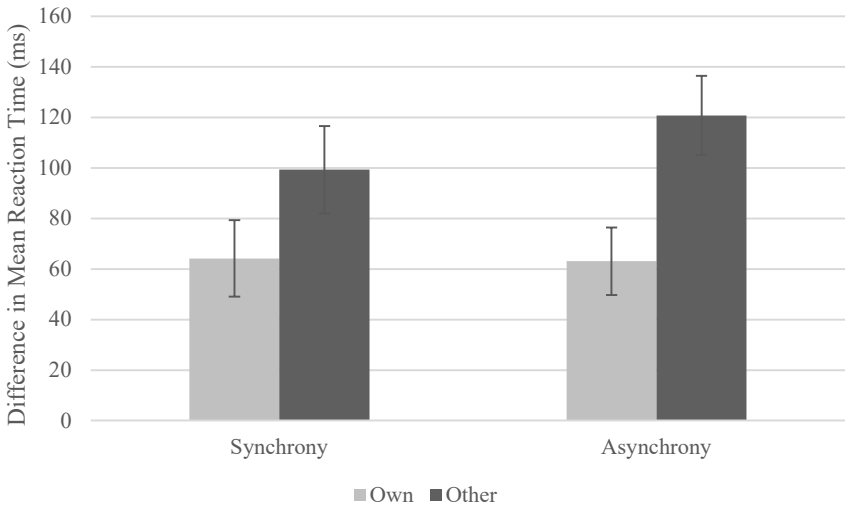


Figure 8: Reaction Time Consistency effects within each Perspective condition for the two Coordination conditions in Study 2.

Inverse Efficiency Score

To determine the speed-accuracy trade off affected by Coordination and from trial condition, the inverse efficiency scores were run through a 3-way ANOVA. Descriptive statistics per trial condition are displayed in Table 9.

Table 9: Means (and Standard Deviations) for Inverse Efficiency Scores in Study 2

	Synchrony	Asynchrony
Own Consistent	737.62 (*140.80*)	753.62 (*175.03*)
Own Inconsistent	883.43 (*275.05*)	900.66 (*247.32*)
Other Consistent	783.79 (*155.78*)	782.02 (*207.93*)
Other Inconsistent	949.24 (*211.66*)	992.90 (*317.84*)

There was a significant effect of Perspective $F(1,87)= 15.01$, $p<.001$, $\eta p^2 =.15$. Participants were slightly faster to reach the correct response in the other perspective condition (M =818.83, SD = 193.85) than when they were asked to make judgements from their own perspective (M =876.99, SD = 215.91). There was no significant effect of Consistency $F(1,87)= 130.33$, $p = .06$, $\eta p^2 =.60$. There were no significant two-way interactions, Perspective x Coordination $F(1,87)=0.02$, $p = .89$, $\eta p^2 = .00$, Consistency x Coordination $F(1,87)= 0.63$, $p = .43$, $\eta p^2 = .01$, Perspective x Consistency $F(1,87)= 2.29$, $p =.13$, $\eta p^2 =.03$. Further, the

Perspective x Consistency x Coordination interaction was also not significant $F(1,87)=0.64$, $p = .43$, $\eta p^2 = .01$.

Additional Measures

To determine the effect of Coordination on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity an independent samples t-test was conducted. The descriptive statistics are shown in Table 10.

Table 10: Means (and Standard Deviations) for Additional Measures in Study 2

	Synchrony	Asynchrony
Similarity	41.78 (*21.57*)	32.52 (*24.56*)
Mind Attribution	3.89 (*.77*)	3.92 (*.61*)
Trust	3.42 (*.39*)	3.29 (*.44*)
Empathy	3.35 (*.40*)	3.20 (*.50*)

The difference in Similarity ratings failed to reach significance $t(88)= 1.54$, $p= .06$, $d= -0.40$. Participants who had a synchronous interaction with their confederate, reported slightly higher ratings of similarity with the confederate (M =41.78, SD =21.57) than participants who had an asynchronous interaction (M =32.52, SD =24.56).

There was no significant difference between Synchronous and Asynchronous groups for perceived Trust of the confederate $t(88)=1.38$, $p= .17$, $d= 0.04$. There was also no significant difference from the scores given for the Mind Attribution scale $t(89)= -0.16$, $p= .87$,$d= -0.03$. Nor for Empathy scores $t(88)= 0.07$, $p= .13$, $d= -0.3$.

2.4.3. Discussion

Study 2 was a replication of Study 1, with two differences. The first was that the participants were collected via Prolific. Participants were only eligible if UK based, but unlike in Study 1, they were not all undergraduate psychology students. The second difference was that participants were randomly assigned to a coordination condition. Application of exclusion criteria meant that Study 2 was underpowered[2]. However, it remains possible to discern how the findings of this study compare as a replication of Study 1.

It was hypothesised that random assignment of participants in this experiment would strengthen the evidence of prior social knowledge influencing visual perspective taking. As in Study 1, we replicated the inconsistency effects found by Samson et al., (2010) and found that those effects were again influenced by prior knowledge of the confederate from a coordinated interaction. Further, as in Study 1, egocentric intrusions were reduced following synchrony which implies that synchronizing makes it easier to ignore your own perspective in favour of your partners. This presents further support for theory of synchrony possibly inducing some merging of self and other.

However, unlike the findings of Study 1, altercentric intrusions following synchronization were no greater than following a failure to synchronize. This difference could occur from the lack of power, a more varied participant sample, or that failing to synchronize provides enough prior social knowledge to have some effect itself. The finding highlights the need to further explore the possible relationship of synchrony and visual perspective taking.

[2] See Appendices for the powered, pre-exclusion criteria analyses

2.5. Study 3

2.5.1. Introduction

Before investigating the relationship of synchrony and VPT, it is necessary to expand upon and confirm the original experimental design. Social interactions in real life are not isolated incidents. On the average day it is reasonable to expect to have numerous interactions with others that require engagement in interpersonal coordination. Some of these interactions will be successful, some unsuccessful and some unworthy of note. Possibly even in quick succession of each other. Studies 1 and 2 followed the pattern of the previous experimental research into interpersonal coordination with a single coordinated interaction with one person. The results of Studies 1 and 2 established that a social context to Level-1 VPT results in egocentric and altercentric intrusions. Study 3 investigates whether the same interaction and intrusion effects are found with multiple interactions with multiple different partners and if one coordination affects subsequent ones.

For the individual, taking on the perspectives of others has been established to be spontaneous and involuntary (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). Perspective-taking occurs without conscious awareness and provides the basis for the cognitive processes of coordination which underly our ability to have an effective and mostly effortless social interaction. Additionally, successful synchrony has been shown to have social and emotional effects, increasing feelings of affiliation between interactants. For example, increased feelings of trust and willingness to cooperate (Miles, Nind, & Macrae, 2009; Richardson & Zimmermann, 2016). Conversely, failure to synchronise within an interaction has proven to have negative impact on perceptions of the interactant partner, causing discomfort or distrust (Schoenenberg, Raake, & Koeppe, 2014).

Social interactions do not occur in a vacuum and there is the assumption that if an individual experiences an awkward interaction due to a failure to coordinate, they will be able to ‘bounce back’. However, the extent to which recovery is possible and the speed at which it can occur is unknown. It is necessary to investigate whether following an asynchronous interaction with a synchronous one would still increase feelings of affiliation to that interaction partner, i.e., might it produce a similar outcome to having no previous interaction.

This study further builds upon the literature as there are limited examples of previous research that have included a control interaction as a baseline comparison to both synchrony and asynchrony. There was difficulty in defining what a control comparison would look like

due to the definition of synchrony as a temporally matched action coordination; you are either in-phase (synchronous) or not (asynchronous). Whilst there can be exploration of what it means to be out of phase, predictably or unpredictably, everything falls under the title of coordination. The control condition of the second study of Wiltermuth and Heath (2009) was for the participant to observe rather than interact. Therefore, it was decided that this would be the control condition for Study 3. Participants would hear music with the same bpm as the video of the confederate tapping (thus providing the perception of coordination with the confederate) but without engagement in the action paradigm. Meaning that the participant is neither actively in synchrony nor asynchrony with the confederate.

Additionally, a methodological concern is addressed in Study 3 by conducting the study as an in-person laboratory experiment. The Pilot and Studies 1 and 2 were run online, using two different programmes and two different participant collection websites. Like Studies 1 and 2, Study 3 was programmed on Gorilla including the onscreen instructions. This ensured that the participants could understand the directions given to them and that they tapped to the beat of the music (bpm) not the tune. There was the additional anticipated benefit in participants being aware of being observed by the experimenter countering potential loss of focus or failure to complete or engage with the experiment.

It was predicted that the Consistency effects would once again be found in all conditions where the participant and confederate could see the same number of discs; that is the speed and magnitude of correct responses would be higher than if the two perspectives were different. The Consistency effect was also expected to be found in the control condition as indication that spontaneous visual perspective taking still occurred. Furthermore, it was predicted that self-other merging could occur again with the synchronous coordination. In control and asynchronous conditions participants will be able to experience egocentric intrusions, taking on the perspective of the confederate having adjusted from their own perspective. However, in the synchronous perspective it is predicted that there would also be greater occurrence of altercentric intrusions, where the participant is unable to ignore the confederate's perspective when judging from their own perspective. This is predicted to occur regardless of the order of coordination interactions.

Participants were expected to have highest feelings of similarity, trust and empathy towards the confederate that they were synchronously coordinated with regardless of the order of interactions. It was not expected that they would feel significantly less similar to the

asynchronous confederate, but that the scores would be closer to the control than to the synchronous confederate. Participants were expected to have relatively neutral responses to the control condition confederate.

2.5.2. Methodology

Overview

This research experiment investigated how participant perspective taking would be affected following specific coordinated interactions with different confederates and how those coordinations would influence perception of each confederate. In addition, it was investigated whether the research data collected online would hold for laboratory-based data collection and if synchrony would have carry-over effects for subsequent interactions. This experiment also included a version of a 'Control' condition. This sought to act as a baseline interaction that was comparable to both Asynchrony and Synchrony.

Participants

A power analysis was carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009)) indicated that to detect a medium effect size, $d = 0.5$, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a sample size of 34 would be needed for an independent samples t-test. Participants were gathered using the SONA system at the University of East Anglia (UEA) or through an advertisement in the UEA Paid Participant Panel. All participants were aged between 18 and 30 and were either an undergraduate or a postgraduate student at UEA.

There were 51 participants in total. But following exclusion criteria only 31 participants were included in the final experiment analysis. An additional exclusion criterion was included in this investigation as 7 participants reported already knowing one of the confederates. Participants were assigned into one of six versions of the experiment. The experimenter controlled which version the participant was shown using a counterbalancing sheet. There were 4 participants (M =22.75, SD =4.50) in Version 1, all of which identified as female. In Version 2 there were 4 participants, all of which were female (M =20.25, SD =2.06), Version 3 had 7 participants with 4 being female (M =21.29, SD =3.55). Version 4 had 5 participants, 3 female (M =21.20, SD =1.26) and Version 5 had 6 participants, 4 of which were female (M =19.00, SD =1.26). Finally, Version 6 had 5 participants, 3 of which were female (M =19.40, SD =1.14).

Design and Materials

This Study used a within-subjects design. All participants completed all the Coordination conditions (Synchrony, Asynchrony and Control) in a different order, controlled by a counterbalancing spreadsheet. The confederates were shown in the same order but

displayed different coordination behaviours depending on the experiment version. In Version 1 participants had a synchronous interaction with the first confederate, an asynchronous interaction with the second and a controlled interaction with the third confederate. Details of each version are displayed in Table 11. The Empathy Quotient, Trust scale, Mental Attribution Scale and Similarity scale were all included as additional measures. All four were worded to specifically refer to the confederate the participant had just interacted with.

Table 11: Counterbalanced coordination interaction order for each experiment version

Condition Analysis Group	Experiment Version	Synchrony	Asynchrony	Control
1	1	1st	2nd	3rd
1	2	1st	3rd	2nd
2	3	2nd	1st	3rd
2	5	3rd	1st	2nd
3	4	2nd	3rd	1st
3	6	3rd	2nd	1st

This Study was completed in the same laboratory that was used in stimuli creation. The Gorilla Experiment Builder (www.gorilla.sc) was used to create and host the six versions of the experiment. The experiment took 35-40 minutes without breaks. As the experiment was much longer than previous iterations, participants were monitored to ensure attention was maintained. Participants were tested in isolation.

Figure 9: Example of a Consistent trial using the first female confederate.

Stimuli

Stimuli for six confederates (3 male and 3 female, all white British and aged between 18-30) were created for this study, example Figures 9 and 10. The 3 confederates were matched to participants by their reported gender identity. Those who did not identify as male, or female were assigned a female confederate.

Figure 10: Chart of all six confederates shown to participants during the debrief to ensure no previous social relationships

For the Coordination task, each participant was shown a video providing 'Asynchrony', 'Synchrony' and 'Control' stimuli. In the 'Asynchrony' video the confederate tapped at a visibly slower rate (80bpm) than the audio track heard by the participants (110bpm). In the 'Synchrony' video the confederate tapped at the same speed as the audio track heard by the participant (90bpm). In the 'Control' video the confederate tapped to a 90bpm track (the same one that was used with in the Synchrony condition), but the participants heard a different 90bpm audio track. Additionally, the tapping of the confederate was not audible so the participant would be unable to synchronize to that auditory cue instead of the music. All videos were 3 minutes in length. For the VPT task, each confederate had 22 images in profile with differing numbers of discs on either side of them (11 facing right, 11 left). In total, 132 VPT slides were created.

Procedure

Participants were seated in soundproof booths with the experimenter present. The experimenter ran the short audio test to ensure the volume was audible to the participant. The participants then filled out the basic demographic information including age and gender. If a participant was ineligible, they were thanked and asked to exit the study.

Eligible participants gave their consent proceeded to the first set of experimental tasks. Participants were given instructions matching to the first Coordination for their Version (see Table 11). In the Synchrony and Asynchrony conditions, participants were asked to watch the video shown and to tap their hand on the flat table in front of them to the beat of the music they could hear. In the Control Coordination version participants were asked to watch the video but not to tap and instead place their hands on the table.

Completion of the Coordination task led immediately into the VPT task with the confederate from the Coordination task acting as the avatar. The procedure of the VPT task did not differ from Studies 1 and 2, nor did additional measures. Participants were then offered a short break, before the experimental tasks were each repeated two more times with different confederates of the same gender as the participant, performing different coordinations.

After the experiment was completed, each participant was asked some further questions. They were assured once again that their responses would be completely anonymous and confidential and would not be shared with the individuals that they saw on the screen. They then had to say which person they felt most similar to and then which person they felt least similar to. The selection offered were numbers 1, 2 and 3 to correspond with the order of

confederates. Participants were then shown the debrief online and asked to inform the experimenter when they had finished reading so that they could receive an additional verbal debrief.

2.5.3. Results

Analyses

To provide clarity, the experimental results were split into two analyses. One analysis examined analysable data across all conditions by grouping participants into condition analysis groups according to which simulated interaction they had first (Table 11). This allowed for more transparency of the within-subjects' design analysis and eased the interpretation of results. Due to the occurrence of order effects which influenced the results, the data was also analysed with a between-subjects' design where only the first interaction and subsequent VPT experimental trials were examined. This did lead to a considerably underpowered study but allows critique.

Three Conditions

A within-subject analysis was conducted wherein the participants from the 6 Versions of the experiment were grouped into the 3 conditions, determined by the type of coordination they experienced first.

Accuracy

To determine the effect of the First Coordinated interaction, Coordination type, Perspective, and Consistency on accuracy rates, a 4-way mixed model ANOVA was conducted. Mean accuracies per trial condition are displayed in Table 12. There was a significant Consistency effect, as expected, for Accuracy $F(1,28)= 51.11$, $p <.001$, $\eta p^2 =.65$. All participants were more accurate when both perspectives were Consistent (M = .95, SD = .04) than when both perspectives were Inconsistent (M = .94, SD = .04). Further, the Consistency x First Condition interaction effect was significant $F(1,28)= 11.32$, $p = <.001$, $\eta p^2 = .45$. However, Consistency x Coordination was not significant $F(1,28)= 2.02$, $p = .14$, $\eta p^2 = .07$.

Table 12: Means (and Standard Deviations) for Accuracy in Study 3

		Synchrony	Asynchrony	Control
Synchrony First	Own Consistent	**.98 (*.04*)**	1.00 (*.00*)	.99 (*.03*)
	Own Inconsistent	**.95 (*.06*)**	.96 (*.06*)	.93 (*.07*)
	Other Consistent	**.94 (*.07*)**	.99 (*.03*)	.98 (*.04*)
	Other Inconsistent	**.84 (*.13*)**	.95 (*.09*)	.90 (*.09*)
Asynchrony First	Own Consistent	.99 (*.02*)	**.97 (*.05*)**	.97 (*.04*)
	Own Inconsistent	.93 (*.09*)	**.83 (*.14*)**	.95 (*.07*)
	Other Consistent	.99 (*.03*)	**.98 (*.04*)**	.99 (*.03*)
	Other Inconsistent	.92 (*.09*)	**.85 (*.01*)**	.94 (*.07*)
Control First	Own Consistent	.94 (*.08*)	.98 (*.06*)	**.97 (*.08*)**
	Own Inconsistent	.98 (*.05*)	.96 (*.07*)	**.81 (*.19*)**
	Other Consistent	.98 (*.04*)	1.00 (*.00*)	**.96 (*.06*)**
	Other Inconsistent	.92 (*.10*)	.93 (*.08*)	**.83 (*.11*)**

For accuracy, there was no significant effect of Perspective $F(1,28)= 3.00$, $p =.09$, $\eta p^2 =.10$. There was a nonsignificant difference between participants accuracy when judging from their own ($M =.92$, $SD =.11$) or the confederate's perspective ($M = .91$, $SD = 0.06$). There was not a significant Perspective and Consistency interaction effect for accuracy $F(1,28)= 3.40$, $p = .08$, $\eta p^2 = .11$. Further there was not a significant Perspective x Coordination interaction $F(1,28)= 1.99$, $p = .15$, $\eta p^2 = .07$, nor a significant Perspective x First Condition interaction $F(1,28)= 1.96$, $p = .16$, $\eta p^2 = .12$.

There was a significant Coordination x First Condition interaction effect $F(1,28)= 11.32$, $p <.001$, $\eta p^2 = .45$. For example, participants were the least accurate for the condition that they started on. Participants who had a Synchronous interaction first were the least accurate in their responses following the Synchronous interaction (M = .93, SD = .04) compared to the subsequent Asynchronous interaction (M = .97, SD = .04) and the Control interaction (M = .95, SD = .05). Participants who had an Asynchronous interaction first were the least accurate in their responses following the Asynchronous interaction (M = .90, SD = .04) compared to the Synchronous interaction (M = .96, SD = .04) and the Control interaction (M = .96, SD = .05). Those participants whose first interaction was the Control condition were the least accurate in the Control condition (M = .89, SD = .05) compared to the Synchronous (M = .96, SD = .04) and Asynchronous (M = .97, SD = .04) interactions. Additionally, there was a

significant Consistency x Coordination x First Condition interaction $F(1,28)= 6.25$, $p <.001$, $\eta p^2 = .31$, wherein participants were the least accurate in condition they started with.

There were no further three-way interactions, Perspective x Consistency x Coordination $F(1,28)= 1.20$, $p = .31$, $\eta p^2 = .04$, Perspective x Coordination x First Condition $F(1,28)= 0.55$, $p = .70$, $\eta p^2 = .04$. Nor was there a four-way interaction of Perspective x Consistency x Coordination x First Condition $F(1,28)= 1.02$, $p = .40$, $\eta p^2 = .07$.

Reaction Times

A 4-way mixed model ANOVA was conducted to determine the effect of the First Coordinated interaction, Coordination type, Perspective, and Consistency on reaction times. Mean reaction times per trial condition are displayed in Table 13.

Table 13: Means (and Standard Deviations) for Reaction Times in Study 3

		Synchrony (*ms*)	Asynchrony (*ms*)	Control (*ms*)
Synchrony First	Own Consistent	**810 (*216*)**	706 (*156*)	713 (*123*)
	Own Inconsistent	**915 (*183*)**	748 (*122*)	758 (*121*)
	Other Consistent	**830 (*199*)**	654 (*123*)	702 (*144*)
	Other Inconsistent	**953 (*198*)**	745 (*167*)	792 (*158*)
Asynchrony First	Own Consistent	704 (*93*)	**797 (*154*)**	706 (*145*)
	Own Inconsistent	783 (*174*)	**848 (*252*)**	772 (*143*)
	Other Consistent	706 (*101*)	**795 (*247*)**	711 (*153*)
	Other Inconsistent	791 (*151*)	**885 (*199*)**	761 (*115*)
Control First	Own Consistent	685 (*114*)	668 (*101*)	**700 (*103*)**
	Own Inconsistent	737 (*138*)	761 (*157*)	**791 (*126*)**
	Other Consistent	632 (*123*)	636 (*138*)	**691 (*108*)**
	Other Inconsistent	715 (*133*)	727 (*169*)	**802 (*172*)**

There was a significant Consistency effect for reaction times $F(1,28)= 103.43$, $p <.001$, $\eta p^2 =.79$. Participants had a slower overall reaction time when Own and Other perspectives were Inconsistent (M = 713.49, SD = 133.33) than when they were Consistent (M =793.47, SD = 138.55). There was no significant interaction of Consistency x Coordination $F(1,28)= 0.30$, $p = .74$, $\eta p^2 = .01$, nor Consistency x First Condition $F(1,28)= 0.47$, $p = .63$, $\eta p^2 = .03$.

There was no effect of Perspective for reaction times $F(1,28)= .22$, $p= .64$, $\eta p^2 = .01$. Further, there was no significant interaction of Perspective x Consistency $F(1,28)= 2.06$, $p = .16$, $\eta p^2 = .07$. Further there was not a significant Perspective x Coordination interaction $F(1,28)= 0.46$, $p = .63$, $\eta p^2 = .02$, nor a significant Perspective x First Condition interaction $F(1,28)= 1.16$, $p = .33$, $\eta p^2 = .08$.

The type of Coordination condition that the participants experienced first had no significant effect on reaction times. A pairwise comparison revealed the greatest mean difference of 65.24ms was between the fastest group, participants who had the Control condition first (M = 711.91, SD = 231.68) and those who had the Synchronous condition first (M = 777.14, SD = 259.03). Those in the Asynchronous condition first were not much faster (M = 771.40, SD = 203.20). There was also no significant effect on reaction times between Coordination conditions irrespective of sequential order $F(1,28)= 2.63$, $p = .08$, $\eta p^2 = .09$. Synchrony had the slowest reaction times (M = 771.49, SD =137.92). Control resulted in the fastest reaction time (M = 741.53, SD = 127.96) with Asynchrony not being far off (M = 747.43, SD = 156.72).

There was a significant Coordination type x First Condition interaction effect for reaction times $F(1,28)= 17.75$, $p <.001$, $\eta p^2 =.56$. Participants were the slowest on the Coordination they started the experiment on. Participants who had a Synchronous interaction first were slowest to respond in the Synchrony condition (M =876.90, SD = 135.25) compared to the Asynchronous (M =713.19, SD = 153.68) or Control conditions (M =741.34, SD = 125.47). Those who started with an Asynchronous interaction were the slowest to respond in the Asynchronous condition (M =831.21, SD = 153.68) compared to the Synchronous (M =745.59, SD = 135.25) and Control condition (M =737.40, SD = 125.47). Similarly, the participants who had a Control interaction first were slowest for the Control condition (M =745.87, SD = 125.47) whereas they were faster to respond in the Synchronous (M = 691.98, SD = 135.25) and Asynchronous (M =697.88, SD = 153.68) conditions.

There were no three-way interactions, Perspective x Consistency x Coordination $F(1,28)= 0.08$, $p = .93$, $\eta p^2 = .00$, Perspective x Coordination x First Condition $F(1,28)= 1.03$, $p = .40$, $\eta p^2 = .07$, Consistency x Coordination x First Condition $F(1,28)= 1.00$, $p = .41$, $\eta p^2 = .07$, Perspective x Consistency x First Condition $F(1,28)= 0.31$, $p = .74$, $\eta p^2 = .02$. Nor was there a four-way interaction of Perspective x Consistency x Coordination x First Condition $F(1,28)= 0.36$, $p = .84$, $\eta p^2 = .03$.

Inverse Efficiency Score

A 4-way ANOVA was performed to analyse the effect of Coordination interacted with First Coordination, Coordination, Perspective and Consistency in a speed-accuracy trade off analysis. Descriptive statistics per trial condition are shown in Table 14.

There was a significant effect of Consistency $F(1,28)= 130.44$, $p <.001$, $\eta p^2 = .82$. Participants were slower when the trials were Inconsistent (M = 889.35, SD = 165.31) than Consistent (M = 733.52, SD = 146.83).

There was also a significant Coordination x First Condition interaction effect $F(1,28)= 25.93$, $p <.001$, $\eta p^2 = .65$ with the coordination which the participants began with being both the slowest and least correct, confirming the presence of order effects. There was a significant Consistency x Coordination x First Condition interaction effect $F(1,28)= 7.80$, $p <.001$, $\eta p^2 = .36$.

Table 14: Means (and Standard Deviations) for Inverse Efficiency in Study 3

		Synchrony	Asynchrony	Control
Synchrony First	Own Consistent	**828.39 (*235.64*)**	706.23 (*155.51*)	722.37 (*136.40*)
	Own Inconsistent	**970.24 (*208.37*)**	788.83 (*175.34*)	817.29 (*112.28*)
	Other Consistent	**898.71 (*271.54*)**	661.22 (*126.78*)	715.24 (*135.81*)
	Other Inconsistent	**1155.84 (*319.41*)**	793.14 (*192.69*)	896.74 (*221.92*)
Asynchrony First	Own Consistent	708.80 (*99.47*)	**821.30 (*168.82*)**	727.24 (*136.40*)
	Own Inconsistent	842.54 (*164.52*)	**1036.71 (*228.90*)**	812.91 (*136.91*)
	Other Consistent	714.29 (*100.35*)	**815.13 (*273.67*)**	720.36 (*157.61*)
	Other Inconsistent	861.40 (*144.54*)	**1048.25 (*229.07*)**	817.61 (*157.53*)
Control First	Own Consistent	738.79 (*175.56*)	688.93 (*125.51*)	**730.76 (*137.84*)**
	Own Inconsistent	748.38 (*126.39*)	797.66 (*173.34*)	**1024.46 (*262.67*)**
	Other Consistent	643.07 (*131.10*)	635.66 (*138.09*)	**726.91 (*150.89*)**
	Other Inconsistent	790.76 (*190.14*)	803.68 (*269.17*)	**1001.76 (*332.71*)**

There was not a significant effect of Coordination $F(1,28)= .90$, $p= .41$, $\eta p^2 =.03$. Participants were slowest in the Synchronous coordination (M =825.10, SD = 159.07) than the Asynchronous (M = 799.73, SD = 173.13) or the Control coordination (M = 809.47, SD =

158.16). Further, there was no significant effect of Perspective $F(1,28)= .45$, $p = .51$, $\eta p^2 = .02$.

There were no further significant two-way interactions, Perspective x Consistency $F(1,28)= 4.32$, $p = .05$, $\eta p^2 = .13$, Perspective x Coordination $F(1,28)= 2.12$, $p = .13$, $\eta p^2 = .07$, Perspective x First Condition $F(1,28)= 1.49$, $p = .24$, $\eta p^2 = .10$, Consistency x Coordination $F(1,28)= 0.66$, $p = .52$, $\eta p^2 = .02$, Consistency x First Condition $F(1,28)= 0.17$, $p = .84$, $\eta p^2 = .01$.

There were no further significant three-way interactions, Perspective x Consistency x Coordination $F(1,28)= 0.64$, $p = .53$, $\eta p^2 = .02$, Perspective x Coordination x First Condition $F(1,28)= .64$, $p = .53$, $\eta p^2 = .02$., Perspective x Consistency x First Condition $F(1,28)= 0.69$, $p = .51$, $\eta p^2 = .05$. Nor was there a four-way interaction of Perspective x Consistency x Coordination x First Condition $F(1,28)= 0.43$, $p = .79$, $\eta p^2 = .03$.

Additional Measures

To determine the effect of the first coordination interaction experienced between Coordination conditions on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity, a split independent samples t-test was conducted (see Table 15).

There were no significant relationships between Similarity ratings for each condition, and which condition the participants experienced first. Which condition the participant had first also had no significant difference on their ratings on the Empathy quotient, the Mind Attribution nor the Trust scale for each condition.

Table 15: Means (and Standard Deviations) for Additional Measures in Study 3

		Synchrony	Asynchrony	Control
Similarity	Synchrony First	**49.13 (*26.84*)**	38.38 (*27.67*)	47.63 (*30.66*)
	Asynchrony First	45.92 (*29.44*)	**44.85 (*23.64*)**	38.31 (*22.33*)
	Control First	40.40 (*25.92*)	42.70 (*24.26*)	**39.40 (*16.86*)**
Mind Attribution	Synchrony First	**4.10 (*.82*)**	3.98 (*.67*)	3.96 (*.62*)
	Asynchrony First	4.18 (*.59*)	**4.21 (*.54*)**	4.21 (*.58*)
	Control First	4.37 (*.70*)	4.27 (*.76*)	**3.99 (*.99*)**
Trust	Synchrony First	**3.24 (*.42*)**	3.20 (*.24*)	3.45 (*.34*)
	Asynchrony First	3.23 (*.27*)	**3.26 (*.30*)**	3.24 (*.36*)
	Control First	3.31 (*.53*)	3.01 (*.46*)	**3.31 (*.46*)**
Empathy	Synchrony First	**3.44 (*.33*)**	3.20 (*.52*)	3.44 (*.49*)
	Asynchrony First	3.24 (*.75*)	**3.26 (*.77*)**	3.38 (*.80*)
	Control First	3.31 (*.46*)	3.53 (*.28*)	**3.50 (*.49*)**

First Condition Only Analysis

A between-subjects analysis was carried out based on the first interaction that participants had. The first analysis of Study 3 shows significant order effects for the confederates and Coordinations on both reaction times. Subsequently, this further exploratory analysis was conducted to review the results without carry-over influence.

Accuracy

A three-way ANOVA was performed to analyse the effect of Coordination (Synchrony, Asynchrony or Control), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) on accuracy. Mean accuracies per trial condition are shown in Table 16.

Table 16: Means (and Standard Deviations) for Accuracy of First Coordination Condition in Study 3

	Synchrony	Asynchrony	Control
Own Consistent	.98 (*.04*)	.97 (*.05*)	.97 (*.08*)
Own Inconsistent	.95 (*.06*)	.83 (*.14*)	.81 (*.19*)
Other Consistent	.94 (*.07*)	.98 (*.04*)	.96 (*.06*)
Other Inconsistent	.84 (*.13*)	.85 (*.09*)	.83 (*.11*)

For accuracy, there was a only a significant Consistency effect $F(1,28) = 31.65$, $p < .001$, $\eta p^2 = .53$. Participants were more accurate when the confederate and participant perspectives were Consistent (M = .98, SD = .04) than when they were Inconsistent (M = .85, SD = .11).

Accuracy was highest for participants who had the Synchronous interaction first (M = .93, SD = .06). However, there was no significant effect for Condition as accuracy was also high for participants who had an Asynchronous interaction first (M = .91, SD = .06) and for participants who had a Control interaction first (M = .89, SD = .06).

There was no significant effect for Perspective $F(1,28) = 1.91$, $p = .18$, $\eta p^2 = .06$. There was a slight tendency for participants to be more accurate when judging from their Own Perspective (M =.87, SD =.13) than when judging from the confederate's Perspective (M =.85, SD =.12). None of the two-way interactions were significant, Perspective x Coordination $F(1,28) = 3.00$, $p = .07$, $\eta p^2 = .18$, Consistency x Coordination $F(1,28) = 1.48$, $p = .25$, $\eta p^2 = .10$, Perspective x Consistency $F(1,28) = 0.16$, $p = .69$, $\eta p^2 = .01$.Further, there was no significant Coordination x Perspective x Consistency interaction $F(1,28) = .72$, $p = .49$, $\eta p^2 = .05$.

Reaction Times

To determine the effect of Coordination, Perspective, and Consistency on reaction times, a 3-way mixed model ANOVA was conducted. Mean reaction times per trial condition are displayed in Table 17.

Table 17: Means (and Standard Deviations) for Reaction Times of First Coordination Condition in Study 3

	Synchrony (*ms*)	Asynchrony (*ms*)	Control (*ms*)
Own Consistent	810 (*216*)	797 (*154*)	700 (*103*)
Own Inconsistent	915 (*183*)	848 (*160*)	791 (*126*)
Other Consistent	830 (*199*)	795 (*252*)	691 (*108*)
Other Inconsistent	953 (*198*)	885 (*199*)	802 (*172*)

For First Coordination conditions analysis, there was only a significant Consistency effect for reaction time $F(1,28) = 43.07$, $p < .001$, $\eta p^2 = .61$. Participants had a slower overall reaction time when both perspectives were Inconsistent (M = 865.62, SD = 167.23) than when both perspectives were Consistent (M =770.37, SD = 173.75).

There was no significant effect for Perspective $F(1,28)= .85$, $p = .36$, $\eta p^2 = .03$. Participants were only slightly faster at judging from their own perspective (M = 810.23, SD = 150.99) compared to judging from the confederate's perspective (M = 825.76, SD = 192.19) but this difference isn't significant. The interaction of Perspective x Consistency was not significant $F(1,28)= .73$, $p = .40$, $\eta p^2 = .03$. Nor was the Perspective x Coordination interaction $F(1,28)= 0.22$, $p = .81$, $\eta p^2 = .02$, nor the Consistency x Coordination interaction $F(1,28)= 0.87$, $p = .43$, $\eta p^2 = .06$

Further, the Coordination x Perspective x Consistency comparison did not yield any significant results $F(1,28)= .06$, $p=.95$, $\eta p^2 =.00$. Participants who had the Control condition first were the fastest to respond correctly (M =745.87, SD = 162.40). Participants in the Asynchronous group were slower (M =831.21, SD = 162.43) but participants in the Synchronous condition first were the slowest (M =876.90, SD = 162.40). However, the mean difference between Synchrony and Control was not significant ($p = .10$). The difference in Consistency effect for each perspective, grouped by Coordination are displayed in Figure 11.

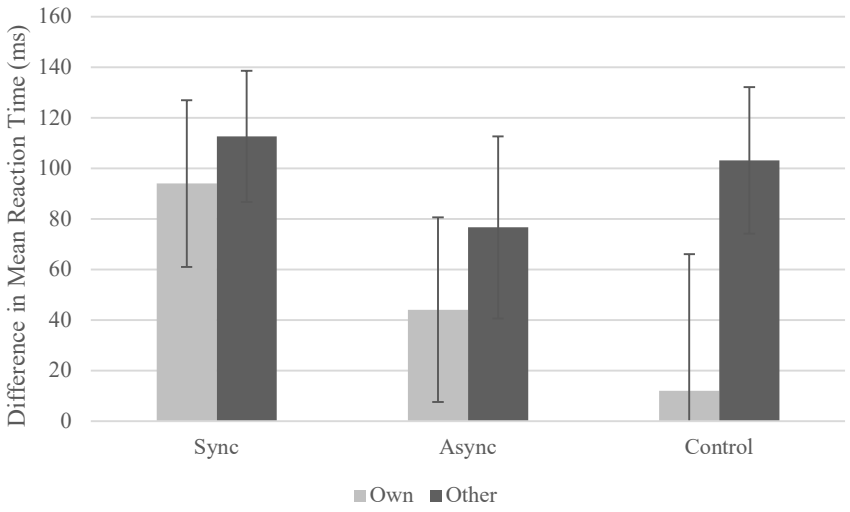


Figure 11: Reaction time Consistency effects within each Perspective condition grouped by Coordination in Study 3.

Additional Measures

To determine the effect of the first coordination task on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity an independent samples t-test was conducted. The descriptive statistics are shown in Table 18. However, there were no

significant differences in the ratings for Mind Attribution, Trust or Empathy, nor Similarity ratings.

Table 18: Means (and Standard Deviations) for Additional Measures of First Coordination Condition in Study 3

	Synchrony	Asynchrony	Control
Similarity	49.13 (*26.84*)	44.85 (*23.64*)	39.40 (*16.86*)
Mind Attribution	4.10 (*.82*)	4.21 (*.54*)	3.99 (*.99*)
Trust	3.24 (*.42*)	3.26 (*.30*)	3.12 (*.25*)
Empathy Quotient	3.44 (*.33*)	3.26 (*.77*)	3.50 (*.49*)

2.5.4. Discussion

One aim of this study was to assess the effectiveness of the experimental design in an in-person laboratory study. Consistency effects necessary to provide confidence in the experiment were found. However, this experiment was three times the duration of Studies 1 and 2, necessitating the presence of an experimenter to ensure continuous engagement with the experiment. Fewer participants were excluded on the basis of exclusion criteria for this investigation. Most were excluded post-experiment due to familiarity with the confederate. This suggests that the laboratory setting may have improved attention to the study and subsequent accuracy. However, as fewer participants were collected overall, online studies remain preferable in terms of recruitment.

Study 3 was ambitious in methodological design. Unfortunately, despite counterbalancing efforts, then immediately following the experiment with two further 'partner' confederates led to significant order effects in both accuracy and reaction times across all starting conditions. Task performance increased with familiarity rather than due to any influence of Coordination, making it impossible to ascertain whether there were carry-over effects of Synchrony or Asynchrony. Analysing the first iteration as a between subject's design allows us to still draw comparisons to Studies 1 and 2.

The primary focus of Study 3 was to further investigate how prior social experience with a confederate would affect the participant's ability to take on their visual perspective. In Studies 1 and 2, prior knowledge of the confederate who acted as the avatar influenced the inconsistency effects of the reaction times. In both studies, Synchrony appeared to result in less egocentric intrusions compared to Asynchrony. In Study 1, Synchrony also resulted in greater altercentric intrusions. However, neither study featured a baseline without active coordination. It was theorised that a Control condition, acting as a baseline, would highlight further which Coordination was driving the effects on visual perspective taking.

In the first block analysis, the Control condition resulted in less interference than either coordinations. Synchrony increased altercentric intrusions, but also increased egocentric intrusion. Synchronising with the confederate subsequently appears to result in more perspective interference for the participant. Possibly indicating further support for the argument of self and other merging. Additionally, Asynchrony resulted reduced egocentric intrusion but also a reduction in altercentric intrusions. Including Control as a baseline comparison allowed it to be seen that both forms of action coordination also influence visual perspective taking.

Prior social knowledge with the perspective taking target (avatar) will influence visual perspective taking. These findings indicate that Synchrony is driving the interference effects in Study 3, but our understanding of the influence of Asynchrony needs to be explored further.

2.6. Chapter Discussion

Two primary aims have been investigated. The first aim was to establish if the effects of engaging in synchrony would affect Level-1 VPT. The second was to expand on literature testing the 'Dot Perspective' VPT task by introducing prior experience with the perspective-taking target, comprising of interpersonal coordination. Experiments have been designed and tested to investigate these aims by testing the hypothesis that an instance of synchrony with a confederate partner would positively influence visual perspective taking, by comparing to situations where there was a failure to synchronise (Studies 1 and 2) and where there was no engagement in interpersonal coordination (Study 3).

Influence of Synchrony on Visual Perspective Taking in Studies 1 and 2

Effects reported by Samson et al., (2010) were observed in Studies 1 and 2. When the participants and confederates' perspectives were inconsistent, the participants responses from both their own and the confederates perspectives were slower and less accurate. As expected, when the number of discs that could be seen by the participant was the same as could be seen by the confederate then the stimuli was easier to process. Thus, the participants could react correctly with more speed from both their own perspective and that of their confederate partner.

Much of the research into mentalising and perspective taking has focused on how participants will affect their own perspective taking ability. Studies 1 and 2 provide strong evidence that prior social experience with the target will also have an impact. In both studies, the extent to which participants showed inconsistency effects was influenced by prior experience with their partner; If the prior experience with the confederate had been synchronous, then the inconsistency effects found differed in comparison to an asynchronous interaction. This provides initial support that synchrony does indeed impact social cognitive mechanisms and evidence that future research into mentalisation should consider how social information from the 'target' can impact perspective-taking.

Results show that synchrony positively influences mentalisation by facilitating perspective taking. Easing the transition from our own perspective to the perspective of the other person. In Studies 1 and 2, a synchronous interaction with the confederate partner prior to the VPT task resulted in fewer egocentric intrusions compared to the asynchronous condition. This suggests that they were better able to ignore their own perspectives when asked to take on their partner's perspective, if participants had previously synchronised. A reduction in egocentric intrusion implies less reliance on self-knowledge. Participants were more

confident in judging from their partner's perspective. This could be due to synchrony leading to participants perceiving a better understanding of their partner's mental states, that the partner is more predictable to the participant. Further, that synchrony influences and arguably brings closer our mental representations of other people to our self-representation, as can occur when engaging in joint action (Sebanz, Bekkering, & Knoblich, 2006). Reddish, Tong, Jong and Whitehouse (2020) found that synchrony created a sense of joint agency, where participants felt degrees of extended self-agency and extended other-agency dependent on perception of influence over the action. Thus, supporting the idea that synchrony affects perceptions of 'self' and 'other' mental representations. A desirable outcome of intentional group synchrony is often to engage in joint action to produce an effect, such as a choir singing producing group cohesion. Therefore, for a perceived preparation of effect, motor synchrony could logically lead to a better ability to take on the perspectives of others through an extension of self-representation. Likely one of the beneficial social or emotional outcomes of synchrony such as increased self-esteem (Lumsden, Miles, & Macrae, 2014).

Study 1 further supports these ideas with the finding that synchrony with the confederate partner resulted in greater altercentric interference effects. Synchronous participants were slower to respond from their own perspective when it differed from that of their partner. This effect was not significant in Study 2, which was underpowered. The greater altercentric intrusions in Study 1 imply further support for the theory that synchrony led to perceptual merging of 'self' and 'other'. Arguably even an extension of the 'other' perspective, as participants found it difficult to separate the 'other' from their own visual experience. However, the difference between Study 1 and 2 might suggest that a prior asynchronous interaction would also affect perspective taking. Further research is needed to clarify whether the increase in altercentric intrusions is an effect of synchrony or of interpersonal coordination by investigating the parameters of asynchrony.

Findings of Study 3 and Control condition

Studies 1 and 2 investigated how synchrony and a failure to synchronise (asynchrony) would influence visual perspective taking, finding that synchrony reduces egocentric intrusions and possibly increases altercentric intrusions. However, the results of Study 2 appear to suggest that a failure to synchronise had a similar effect of increasing altercentric intrusions. To investigate this further, a baseline Control condition was added in Study 3. The inclusion of a Control condition as a comparison is not an entirely novel addition, but there are limited

examples in the literature (Wiltermuth & Heath, 2009). For Study 3, the Control condition provided prior social knowledge by showing the participant their confederate partner tapping to music. However, as the participant was instructed not to actively engage, there was no simulation of a coordinated interaction. Inclusion of a baseline Control condition allowed consideration of whether synchrony or a failure to synchronise was driving the interference effects.

Due to the significant impact of order effects, few conclusions can be drawn from Study 3 in its entirety. Familiarity with the tasks meant that both accuracy and reaction times improved, regardless of the prior knowledge of social experience with the confederate partners. Due to order effects being dominant, analysis of Study 3 outcomes in their entirety did not support the findings of Studies 1 and 2. However, analysis on the first condition where the order effect is excluded suggested tentative corroboration. Analysing the first condition of Study 3, we see that synchrony results in more altercentric intrusions and egocentric intrusions than the inactive Control condition. Asynchrony resulted in more altercentric intrusions, but fewer egocentric intrusions compared to the Control condition. The Control condition had the least significant interference effects overall. We can theorise that the social context of the confederate partner alone (i.e. the Control condition) was not enough to cause altercentric interference. This provides further evidence that inconsistency effects can be impacted by the prior experience of interpersonal motor coordination with the confederate partner and that failing to synchronise also has influence albeit to a lesser degree than synchrony.

Methodological variations

There were only the resources to adequately compensate the number of participants determined by power analysis. Unfortunately, applying the exclusion criteria meant that although sufficient data had been collected, not all could be included. Therefore, in planning Studies 4 to 9, maximising the power of the studies became the priority. This required that the participants be sorted into experimental conditions only, rather than including a baseline control condition. Future research into interpersonal coordination, particularly in synchrony, should consider the inclusion of a Control condition if resources and time constraints allow.

The primary modification of the Samson et al., (2010) ‘dot perspective’ VPT task for this research was the use of a confederate the participant had prior social knowledge of as the perspective taking target (avatar). There was a further modification for this investigation involving the trial presentation design. In their original 2010 paper, the authors digressed from

a pseudo-random order to a 'blocked' trial presentation design. Within a given block, participants only ever needed to report one perspective, removing the need to compute both perspectives. However, for uniformity between Studies 1, 2 and 3, the trials were presented in a pseudo-random order. Whilst this could present the same issue as the random design in the original experiment, Samson et al., only found the speed of self-perspective judgements increased on both Consistent and Inconsistent trials and no differences in levels of intrusions. Therefore, this methodological change is not deemed to be a problem for data interpretation.

Proposed explanations and further investigations

It is concluded here that Studies 1-3 provide initial evidence that prior social knowledge of a partner will influence visual perspective taking and that synchrony can therefore impact social cognition beyond explicit judgements. A synchronous interaction prior to a VPT can reduce egocentric intrusions and increase altercentric intrusions (as shown in Study 1). The following investigations explore two proposed explanations for these effects. The first explanation, investigated in Chapter 3, is that synchrony leads to interference effects in perspective taking because it increases the participants' perception of similarity to their interaction partner. The second explanation, investigated in Chapter 4, is that synchrony leads to interference effects in perspective taking because it increases the participants' perception that they can apply predictive models to their interaction partner.

Explanation based on Similarity

Studies 1 to 3 asked participants a series of questions about their perceptions of the confederate at the end of the experiment, with the aim of assessing the participants mentalization of their interactant partner. In both Studies 1 and 2, participants who had a synchronous interaction with their confederate partner reported significantly higher feelings of similarity between themselves and the partner than participants who had an asynchronous interaction.

The anchoring and adjustment heuristic theorises that people use their own mental states as an anchor from which they adjust to guide their inferences of the mental states of others (Epley, Keysar, Van Boven, & Gilovich, 2004). We are inherently egocentric; naturally assuming reliance on our self-knowledge as a representation of others' mental states would be beneficial. Therefore, we logically assume that being similar to another person would make it easier to take on their perspective. However, research has found that successful perspective taking is often dependent on maintained

recognition of the differences between self and other (Todd, Hanko, Galinsky, & Mussweiler, 2011). If synchronising with the confederate partner gives the participants the perception that they and the confederate are socially similar, then perhaps this can explain the increase in interference effects following synchrony; participants were less able to recognise the difference between the self and other perspectives. Chapter 3 provides an investigation of how perceptions of similarity with the interactant partner may influence visual perspective taking.

Explanation based on Predictability

The pilot study found anecdotal evidence that participants in the asynchronous condition expressed discomfort or concern that they had not executed the experimental instructions correctly, as they were tapping to the beat which never matched their partners tapping. It is possible that participants were intuitively aware that they were failing to synchronise, something that is known to cause discomfort and distrust of an interaction partner (Schoenenberg, Raake, & Koeppe, 2014). If this is the case then the asynchronous participants may have experienced anxiety which has been found to impair spontaneous visual perspective taking with social agents, increasing both egocentric and altercentric intrusions (Todd & Simpson, 2016). However, Studies 1 to 3 used different stimuli to the pilot and the extent to which the asynchronous condition was interpreted as a failure to synchronise is unknown. The difference in altercentric interference levels between Studies 1 and 2 and the levels of interference in the asynchronous condition compared to the baseline control condition in Study 3 instead direct us towards a different research question. What degrees of asynchrony are still processed as interpersonal coordination?

The focus of this Chapter has been how synchrony impacts social cognition, specifically Level-1 VPT. Evidence is provided that it does indeed lead to interference effects in both ‘self’ and ‘other’ perspective judgements. However, synchrony has been historically considered a form of interpersonal coordination alongside behavioural mimicry (Bernieri & Rosenthal, 1991). Behavioural mimicry, whether leading or following, has a delay between action and imitation but is still interpersonal coordination. Whereas both in-phase (temporally matched movements in the same direction) and anti-phase (temporally matched movements in opposite directions) are both considered as definitions of synchrony. All forms of interpersonal action

coordination require prediction of interactant partners (Keller, 2008). Manipulating participants perceptions of the predictability of their interaction partners may help us further understand the differences in the interference effects found between synchrony and asynchrony conditions and between Studies 1, 2 and 3. Chapter 4 investigates how prediction within interpersonal coordination influences visual perspective taking.

Chapter 3

Similarity and Visual Perspective Taking

3.1 Introduction

Studies 1, 2 and 3 investigated whether prior synchronous engagement would have influence in a subsequent visual perspective taking (VPT) task and found that perceived social knowledge of the confederate through synchronising causes the participants to draw their mental representations of 'self' and 'other' closer together, almost merging the 'self' and 'other' perspectives. This affects the participants' ability to differentiate perspectives. In establishing that there is a relationship and an effect of synchrony on VPT, explanations for the effect need to be investigated. This Chapter investigates, through Studies 4 to 7, the possible contributions of similarity.

3.1.1. Similarity and Perspective Taking

Similarity is an asset in social interactions, encouraging positive pro-social outcomes with friends and strangers alike. Perceptions of similarity in research has led to self-reported positive feelings and social closeness between interactants (Liviatan, Trope, & Liberman, 2008). Determining whether someone is similar to ourselves is reliant on sorting through the social information we have about them. We engage in social categorisation, generalisation, stereotyping and social comparison to try and ascertain how the other person measures up compared to ourselves (Ames, 2004; Billig & Tajfel, 1973; Festinger, 1954; Gawronski & Quinn, 2013).

The 'self' is treated as a habitual reference point in various judgements, including similarity. We judge similarity by comparing others to ourselves rather than the other way around (Holyoak & Gordon, 1983). Further, we are motivated to do so as we tend to believe that our own traits are more useful to goal outcomes than traits of others. We know our own strengths and abilities and can utilise them faster than attempting to learn someone else's (Kunda, 1987). Toma, Corneille and Yzerbyt (2012) found that individuals will overly attribute the success of their cooperation to their egocentric beliefs of similarity. This not only applies to unfamiliar others, but romantic partners too. Those who feel the most understood, happy and confident in their relationships are likely benefiting from their own egocentrism (Murray, Holmes, Bellavia, Griffin, & Dolderman, 2002). Considering a partner through an egocentric filter creates assumptions of mirroring traits, perceiving similarities that have no grounding but nonetheless lead to relationship satisfaction. These self-serving interests shape our cognitive processing of *all* others.

3.1.2. Similarity and Embodiment

Egocentric biases mean that perceptions of similarity are malleable and open to interpretation. Two people can meet the same individual but 'see' them completely differently depending on their own perceptions. As such, there is not one singular definition of similarity. Similarity can be recognised or perceived in multiple different dimensions, both consciously and unconsciously. One dimension of similar perspectives uses embodiment of the perspective taking target. Embodied cognition emphasises that perception and action are not separate in our thinking. Therefore, when considering similarity, the embodiment account would suggest that when we are physically similar to someone, it is easier to mentally adopt their position as bodily experiences play a key role in cognitive processes. Embodiment suggests that individuals use their internal experiences and information to interpret social contexts through simulation (Goldman, 2006). We understand others by mentally re-enacting their actions and perceptions, which should be easier to simulate if they are similar to us. However, Valerjev and Dujmović (2017) used a version of the 'dot perspective' VPT task where the participants had to embody the avatar in a 3D virtual space. Whilst they did find a consistency effect, they did not find any interference effect for the skin colour of the avatar, implying that social information of physical similarity was insufficient.

Our subjective feelings shape our social judgements. The way we perceive other people to be. When participants judge how hungry or thirsty a hiker might be, they mentally embody the hiker but are biased based on their own physical state, e.g. predicting that the hikers would be thirstier when they themselves had exercised (Van Boven & Loewenstein, 2003). Bodily feelings are reference points that can be projected to the world or within social lives, and social projections of feelings can reflect more general projections of similarity. However, these social projections are also constrained to assumptions of similarity. O'Brien and Ellsworth (2012) replicated prior studies in this area and found that the effect of visceral influence on social judgements vanished when participants believed the other people held opposing political views to their own. This suggests that embodied cognition is limited by our own internal experiences and therefore, taking on the perspective of a similar 'other' should be easier.

3.1.3. Similarity and Mentalising

Comparatively, the mentalising account for perceptions of similarity assume that we have a representation of our own mental states and have a representation for that of others. Further to this, recognising when someone is similar or different to us helps the formation of

the mental representation for the other person. We may not confidently know the minds of others, but we know our own. Perspective taking research is mostly in agreement that we are all naturally egocentric, which impacts our cognitive mechanisms as well as our social attitudes. Our egocentric bias entails that we perceive our own thoughts, feelings and opinions to be the norm (Ross, Greene, & House, 1977). With the assumption of our own mental state being the standard, others seeming to not adhere to this 'norm' by differing from us, is processed as being socially revealing information. Lacking commonality provides us with social information which we use to build our mental representation of this other person. However, when others do adhere to our assumed 'norm' we project our representation of 'self' and our own characteristics onto them.

In theory, perceiving that someone has mental states and attitudes that are similar to our own, should make it easier to take on their perspective. As we know our own mind, we might expect that being able to rely on our own mental states would aid the perspective taking process. However, as we have established, our egocentric bias is self-serving and tricks us into believing we are considering the mental states of others when we are actually projecting our own mental states onto them. In-group avatars induce more egocentric intrusions in participants than out-group avatars (Simpson & Todd, 2017). Todd, Hanko, Galinsky and Mussweiler (2011) found that we have the most success taking on the perspective of others when we are more aware of the differences between our mental representations of 'self' and 'other'. The mentalising account of similarity suggests that a perceived mind-set of difference limits our egocentric biases, making perspective taking easier. It is not necessarily the case that having similarities with another person will make it more difficult to take on their perspective, but specifically perception that they have similar mental states.

3.1.4. Synchrony and Similarity

Research has established that 'self' and 'other' merging can occur for perspective taking and can occur both bodily and facially as a result of synchrony. Participants have confused the face of another person with their own following looking at a morphed face which was being touched in synchrony to their own (Tsakiris, 2008). Another study found that participants felt closer and more similar to a stranger following synchronous facial stimulation (Paladino, Mazzurega, Pavani, & Schubert, 2010). They experienced more 'self' and 'other' merging on both on a bodily and a conceptual level than participants who had an asynchronous facial stimulation. Participants felt they facially resembled each other more, reported more positive

affiliation and had results comparable to the 'rubber hand illusion' (Botvinick & Cohen, 1998). This investigation (Chapter 2) has found evidence to bridge the gap, wherein synchrony can influence our ability to separate our own perspective from that of others and resulting in 'self' and 'other' merging.

In Studies 1 and 2, participants who had the synchronous interaction significantly self-reported the confederate as being more similar to themselves than the participants who had an asynchronous interaction. This was the only one of the additional measures to yield significant differences between the two conditions. Indicating that either failing to synchronise (asynchrony) made participants feel less similar to the confederate or that synchrony made them feel more similar. Either way, the possibility of a perception of similarity having a role is worthy of exploration.

As previously discussed, synchrony can have numerous emotional and social outcomes (Hove & Risen, 2009). Synchrony not only affects how we feel about others, but also how we treat them and see them in relation to ourselves. Synchronising with others facilitates social cohesion and joint action to achieve joint goals. Increasing perceptions of similarity has been argued to be a facet of this, as this investigation is not the first to note the link between synchrony and perceptions of similarity. Valdesolo, Ouyang and DeSteno (2010) found an increase in perceptions of similarity and feelings of connectedness amongst participants rocking synchronously in rocking chairs. Rabinowitch and Knafo-Noam (2015) found that children who had participated in a rhythmic synchronous tapping task considered their interacting partner to be more similar to themselves compared to children engaging in an asynchronous interaction or no tapping interaction at all. There is a general consensus in the literature that there is a link between synchrony and similarity. Particularly, that synchrony affects both similarity and VPT, but it remains unclear whether the effect on similarity is responsible for the effect on VPT performance.

Successful cooperation has often been attributed to perceptions of similarity to the self between the interactants (Toma, Corneille, & Yzerbyt, 2012). Valdesolo and DeSteno (2011) have been proposed that increases in perceived similarity following synchrony acts as a mediating factor, facilitating positive social interaction. Theoretically, synchrony acts as a perceptual marker of similarity which then encourages altruism and compassion. Synchrony signals similarity, possibly by bringing the concept of 'other' closer to our mental representations of 'self', which then increases liking, sense of belonging and other subsequent

socio-emotional responses (Liviatan, Trope, & Liberman, 2008; Chartrand & Bargh, 1999). Literature measuring perceptions of similarity as an outcome, usually use self-report questionnaires after an interaction. This leaves a gap in understanding how established perceptions of similarity may be influenced by synchrony.

3.1.5. Overview

In Chapter 3, two definitions of similarity relevant to the research paradigm are investigated. In Study 4, the effect of 'Physical Similarity' or visual cues of similarity on VPT is explored. Cues used for identification, such as gender or race, may change the participants' perspective taking of the avatar in the modified 'dot perspective' VPT task. In Studies 1 to 3, the coordination task had a visual component, participants saw the confederate acting in the same way as they had been asked to do. It is plausible that, in seeing the confederate's actions coordinating with their own, some of the social information gathered were visual cues for categorisation and comparison which then affected perspective taking. Study 4 investigates whether having similar, or different, physical attributes to the confederate would have the participant change the participants starting point for mentalisation or embodiment by applying a Similarity manipulation and using a real confederate in a modified 'dot perspective task'.

The second definition of similarity employs the idea that a confederate might be perceived as being more similar to the participant due to the engagement in motor synchrony. Chapter 3 explores the relationship between synchrony and perceptions of similarity and between perceptions of similarity and perspective taking. But understanding of how the three factors might relate to each other is unclear. Studies 5 to 7 attempts to manipulate the participants' mental representation of the confederate by manipulating them to believe the confederate' mental states are similar or dissimilar to their own in order to investigate the influence on VPT. In Studies 6 and 7, the coordination task used in Studies 1 to 3 is introduced in addition to the Similarity manipulation to investigate the relationship and effects of both synchrony and perceived similarity on VPT.

3.2. Study 4: Physical Similarity

3.2.1. Methodology

Overview

Study 4 investigates whether physical cues of similarity to the confederate would interfere with a participant's ability to separate 'self' and 'other' mental representations in the VPT task. This study will extend the literature into Similarity and Perspective taking by using a real confederate as the avatar standing in a real room for the 'dot perspective' VPT task. Study 4 tests how physical similarity might affect mentalisation processes, therefore, the coordination task does not feature.

Participants

A power analysis based on the pilot and Studies 1 and 2 was carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009). Results indicated that to detect a medium effect size, $d = 0.5$, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 128 would be required for an independent samples t-test. Participants were only eligible for this study if they were aged between 18 and 30, used a laptop or computer and identified their ethnicity as 'White British'. These requirements were included in the Prolific advertisement but were further built into the study so if participants indicated they did not meet these requirements they were automatically thanked and rejected. The sample was balanced by gender.

Following advertisement on Prolific in August 2022, 129 participants were collected. After application of the same exclusion criteria used in Studies 1 to 3, 89 were included in the final analyses. Participants were randomly assigned to a 'Similarity' condition: High or Low. The 'High Similarity' group had 42 participants (M*age* = 24.55, SD =3.54, 14 male, 9 left-handed). The 'Low Similarity' group had 46 participants (M*age* = 24.57, SD =3.39, 16 male, 8 left-handed).

Design and Materials

This experiment used a mixed design. The between-subjects' factor was Similarity; High Similarity or Low Similarity. There were two within-subjects' factors, the first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times in ms).

The Gorilla Experiment Builder (www.gorilla.sc) was used to create and host the experiment for online data collection. As previously stated, all participants identified as 'White British' and gave their gender identification before getting into the experiment. Participants were all matched to a confederate of the same gender. However, as in Study 2, only male and female confederates had been programmed so any participant who reported themselves to be 'Non-Binary', 'Other' or 'Prefer Not to Say' were shown the female confederate. Half (64) of the participants were shown a confederate who was white, and 64 participants were shown a confederate who was not white (see Figure 12).

Figure 12: The four confederates that were used as avatars in Study 4

Participants were asked to complete the additional measures questionnaires of Mind Attribution Scale (Kozak, Marsh, & Wegner, 2006), Empathy Quotient (Baron-Cohen & Wheelwright, 2004), Trust scale (See Section 2.3.1.) and to rate their similarity to the images of the confederates used as a perspective taking target in this modified version of the VPT task. The background of the confederates was a standardised neutral laboratory setting and all

confederates were dressed in neutral casual clothes. There were 22 images of each confederate in profile with differing numbers of discs on either side of them (11 facing right, 11 left), 88 images in total for this experiment.

Procedure

Before being asked for demographic information to ensure eligibility, participants were first provided with a consent form and an option to terminate the experiment if they wished, The demographic questions comprised of whether English was the participants primary language, their preferred gender identification (which would guide which confederate they saw), their age in months and years (rejected if above or below the aforementioned age limits) and what device they were completing the experiment on (anything other than laptop or computer led to the participant being rejected). This study also asked the participants their ethnicity as only White British participants were eligible to take part in Study 4. Therefore, any other response would be directed to the rejection node.

Those eligible immediately proceeded to the modified VPT task. This experimental task did not differ from Studies 1 to 3. The 'avatar' was a static 2D image of the confederate of the same gender as the participant. The Similarity manipulation determined whether the confederate acting as the avatar was of same or a different race to the participant. Following the VPT task participants were informed that they would be asked some questions regarding their perceptions of the person that they had just seen (the confederate). They were encouraged to answer honestly and assured that their responses would be anonymous and never seen by the confederate. Upon completing the experiment participants were reminded that they were welcome to contact the researcher if they had any questions and then received compensation for their time.

3.2.2. Results

Analyses

The primary analysis was a 2x2x2 mixed-model analysis of variance (ANOVA) with Perspective (Self or Other) and Consistency (Consistent or Inconsistent) as the within-subjects variables and Similarity (Similar or Dissimilar) as the between-subjects factor. Inverse efficiency scores were calculated for this and subsequent Studies. However, the findings of the speed-accuracy trade-off analyses failed to reveal much more than the accuracy and reaction times analyses found in isolation. As such, the results of the inverse efficiency analysis for Studies 4 to 6 are in the Appendices.

Again, only the matching trials, where the correct response was 'yes', were included in the analysis. An alpha level of 0.05 was used for all statistical tests. The number of timed-out trials (no response within 2000ms) was recorded, but removed from the initial analysis, in accordance with the procedure reported by Samson et al., (2010).

Accuracy

Mean accuracy scores were analysed using a three-way mixed model ANOVA (see Table 19). For the overall experiment, there was a expected significant Consistency effect $F(1,86)= 89.62$, $p <.001$, $\eta p^2 = .51$. Participants were more accurate when both perspectives were consistent, when the confederate's perspective was Consistent with their own perspective (M = .96, SD = .06) as opposed to when both perspectives were Inconsistent (M = .88, SD = .08).

Table 19: Means (and Standard Deviations) for Accuracy in Study 4

	High Similarity	Low Similarity
Own Consistent	.96 (*.06*)	.96 (*.08*)
Own Inconsistent	.85 (*.12*)	.89 (*.09*)
Other Consistent	.97 (*.06*)	.96 (*.07*)
Other Inconsistent	.85 (*.10*)	.91 (*.09*)

There was a significant Consistency x Similarity interaction $F(1,86)= 9.80$, $p = .002$, $\eta p^2 =.10$. There was a much larger Consistency effect in the High Similarity condition (Consistent M = .97, SD =.06; Inconsistent M =.85, SD = .08) than the Consistency effect for the Low Similarity condition (Consistent M = .96, SD = .05; Inconsistent M = .90, SD = .07).

However, the effect of Perspective was not significant on accuracy $F(1,86)= .71$, $p = .40$, $\eta p^2 = .01$. Further, there was no significant Perspective x Consistency interaction $F(1,86)= .00$, $p= .98$, $\eta p^2 = .00$. The Perspective x Similarity was also not significant $F(1,86)= 0.02$, $p= .90$, $\eta p^2 = .00$. Additionally, the three-way interaction of Perspective x Consistency x Similarity was not significant $F(1,86)= 0.76$, $p= .39$, $\eta p^2 = .01$.

Reaction Times

Mean reaction times were also analysed with a three-way mixed model ANOVA (see Table 20). There was a significant effect of Consistency $F(1,86)= 168.70$, $p <.001$, $\eta p^2 = .66$. Participants were much faster to respond correctly when the perspectives were Consistent (M = 739.29, SD = 141.70) than when they were Inconsistent (M = 837.93, SD = 167.19). The difference in Consistency effects within the Similarity conditions is illustrated in Figure 13.

Table 20: Means (and Standard Deviations) for Reaction Times in Study 4

	High Similarity (*ms*)	Low Similarity (*ms*)
Own Consistent	791 (*180*)	717 (*128*)
Own Inconsistent	868 (*189*)	795 (*151*)
Other Consistent	734 (*167*)	715 (*119*)
Other Inconsistent	864 (*204*)	825 (*169*)

There was a significant Perspective x Similarity interaction $F(1,86)= 6.44$, $p =.01$, $\eta p^2 =.07$. Participants correct responses in the Low condition were faster than those in the High Similarity condition but little difference in their reaction times between Own (M = 756.39, SD = 154.21) and Other perspective judgements (M = 769.59, SD = 156.01). However, in the High Similarity condition, participants were much faster judging from the confederate's perspective (M = 798.96, SD = 579.52) than from their own perspective (M = 829.50, SD = 154.21).

Additionally, there was a significant Perspective x Consistency interaction $F(1,86)= 5.55$, $p = .02$, $\eta p^2 = .00$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(86)= -7.04$, $p <.001$, $d = 0.79$. And a numerically larger Consistency effect when judging from the confederate's perspective $t(86)= -9.63$, $p <.001$, $d = 1.26$.

There was no significant effect of Perspective $F(1,89)= 5.47$, $p = .02$, $\eta p^2 = .04$. Nor a significant Consistency x Similarity interaction $F(1,86)= .37$, $p =.54$, $\eta p^2 = .00$. Furthermore, there was no significant three-way interaction $F(1,89)= .34$, $p =.56$, $\eta p^2 = .00$.

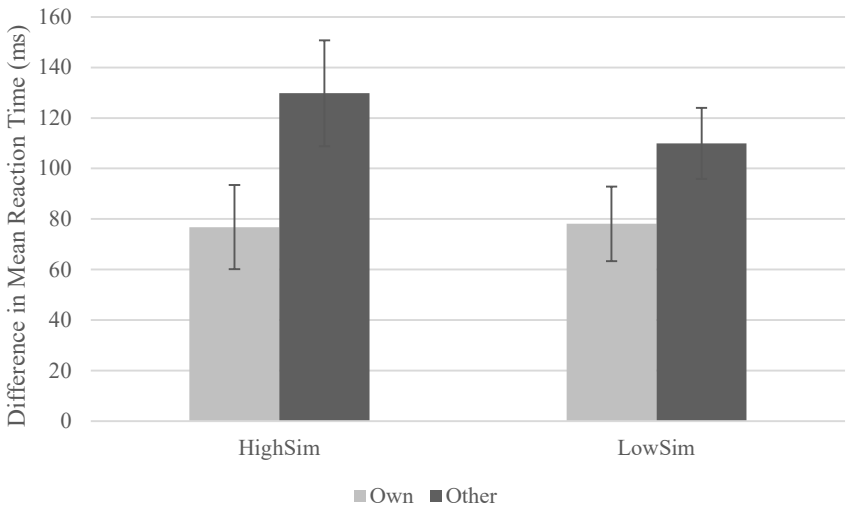


Figure 13: Reaction time Consistency Effects within each Perspective condition for the two Coordination conditions in Study 4.

Additional Measures

Independent samples t-tests were used to investigate the effect of Similarity on ratings of Mind Attribution, Trust, Empathy, and self-reported Similarity (see Table 21). The sole significant effect was on feelings of empathy towards the confederate. Participants who were manipulated to have less physical similarity with the confederate (Low Similarity) were more empathetic towards the confederate (M = 3.44, SD = .37) than those who were more physically similar (M = 3.23, SD = .50) $t(86)= -2.32$, $p = .02$, $d = 0.50$.

Table 21: Means (and Standard Deviations) for Additional Measures in Study 4.

	High Similarity	Low Similarity
Similarity	38.83 (*21.26*)	44.63 (*22.48*)
Mind Attribution	3.96 (*.82*)	4.08 (*.67*)
Trust	3.27 (*.45*)	3.33 (*.45*)
Empathy	3.23 (*.50*)	3.44 (*.37*)

There was no significant difference between Physically Similar and Physically Dissimilar participants self-reported ratings of perceived similarity $t(86)= -1.24$, $p = .22$, $d = 0.27$. Additionally, there was no significant difference between Similar and Dissimilar groups for perceived Trust of the confederate $t(85)= -.59$, $p = .43$, $d = 0.17$. There was also no significant difference from the scores given for the Mind Attribution scale $t(86)= -.79$, $p = .56$, $d = 0.17$.

3.2.3. Discussion

The aim of this experiment was to assess the effects of visual cues of similarity on VPT. Using a real confederate in a real room for the 'dot perspective' VPT task was not novel when considering Studies 1-3 but was for the literature into similarity and perspective taking. Being physically similar to the confederate avatar was anticipated to influence VPT by impacting interference effects. Similarity has previously been shown to limit perspective taking as being able to rely on self-knowledge to judge from the 'other' perspective means the presence of egocentric biases. These biases lead us to believe that we are perspective taking when in reality we are projecting our 'self' mental representation (Todd, Hanko, Galinsky, & Mussweiler, 2011).

The hypothesis for this experiment was that when the confederate was physically similar to the participant, the participant would experience more interference effects. Specifically, that physical similarity would lead to more egocentric intrusions due to projection of self rather than mentalising the confederate 'other' in the VPT task.

Our findings indicate that this was the case, despite participants self-reported Similarity being on average contrary to the experimental manipulation. While the High and Low Similarity groups experienced equivalent levels of altercentric intrusion, the High Similarity group experienced more egocentric intrusions when trying to judge from the 'other' perspective. Participants who were judging from the perspective of the 'other', when that 'other' was physically similar to them, appeared to struggle to effectively take on the 'other' perspective and disregard their own.

These findings contrast those of Valerjev & Dujmović (2017), who investigated whether skin colour would influence VPT in a differently modified version of the 'dot perspective task', using vases rather than dots and 3D model avatars in an open space. They found the inconsistency effect, but did not find an interaction between interference effects and skin colour. They argued that the social information of skin colour was not enough to result in different interference effects in VPT. The findings of Study 4 suggest that using real confederates in a real room caused participants to unconsciously process the physical similarities and apply socio-cognitive processes, explaining the difference in findings.

The findings of the Additional Measures indicate that the Similarity manipulation was not strong enough. Both conditions reported low to medium feelings of Similarity to the confederate, suggesting that manipulation of race was possibly too subtle. Differences in

Similarity may have been processed unconsciously by the participant, but alongside the confines of online research, this does limit the possibilities of physical similarity as a manipulation.

3.3. Study 5: Perceived Similarity

3.3.1. Methodology

Overview

Study 5 investigated whether having a perception of Similarity with the confederate would influence participants VPT performance. Once again, this study extends the literature into Similarity and perspective taking with a novel Similarity manipulation, namely a real confederate acting as the avatar in the VPT task. The coordination task will not feature in this study, as how perception of similar mental states might affect mentalisation processes was being tested.

Participants

A power analysis based on Study 4 (carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009)) indicated that to detect a medium effect size of consistency, d=0.5, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 128 was required for an independent samples t-test, 64 participants in each Condition. The experiment was advertised on SONA and ran between September 2022 and February 2023. To minimise the potential for additional perceptions of similarity or difference beyond the manipulation within the participant pool available, only female participants who were between ages of 18 and 30 were eligible. 151 participants were collected. 98 were included in analyses following exclusion criteria. There were 39 participants in the High Similarity condition (M*age* =19.33, SD =1.24) and 59 in the Low Similarity condition (M*age* =19.20, SD =1.30).

Design and Materials

The investigation used a between subjects' design. There were two within subject factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. The between subjects' factor was Similarity; High or Low Similarity. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times, in ms).

The Gorilla Experiment Builder (www.gorilla.sc) was used to create and host the experiment for online data collection which was proven to be reliable in Studies 1 to 4. As with previous investigations, VPT was measured using a modified version of the Samson et al., (2010) task. Following the conclusion of their tasks, participants were required to fill out a

Mind Attribution Scale, Empathy Quotient and Trust Scale as well as provide a rating on a similarity scale in relation to the confederate.

Similarity was manipulated and controlled for participants in two groups. Participants were randomly assigned to either the High Similarity or the Low Similarity group and were told that the questions were gathering further demographic information about them as their responses would be used to match them to a "participant from a previous study". Depending on the condition participants were sorted into, they were told they'd be matched with someone who's responses would have a maximum similarity rate of 25% (Low Similarity) or minimum similarity rate of 75% with their own responses. However, all participants were subject to the same deception as they were all matched with the same (white, female) confederate regardless of their questionnaire responses. This was controlled to reduce the possibility of participants making additional similarity judgements which couldn't be measured. To give further credence to the deception, participants in the High Similarity condition were all told that their partner was an 87% match and participants in the Low Similarity condition were told a 17% match. The background of the confederate was standardised to be a neutral laboratory setting and they were dressed in neutral casual clothes. There were 22 images of the confederate in profile with differing numbers of discs on either side of them (11 facing right, 11 facing left).

The 24-question Similarity questionnaire was created using the examples of pre-screener questions from Prolific[3]. The questions began with the standard demographic questions Studies 1 to 4 asked before continuing to cover topics such as hobbies, relationships, health, education, career, beliefs. Example questions included "Do you believe in climate change?", "What is your relationship status?", "Do you play a musical instrument, if so for how many years?", "Do you have normal or corrected-to-normal vision?". The questions were presented as drop-down response options, again following the guide of the Prolific screener questions. All questions included a 'Prefer not to say' response option.

Procedure

Participants were first provided with a consent form and option to terminate the experiment if they wished. Consenting participants were immediately asked some demographic questions, which assessed if they were eligible and had noted the study participation requirements.

[3] The 24 item questionnaire is included in the Appendices

Those eligible proceeded to the main questionnaire. Participants were also assured that their demographic information would be kept strictly confidential and will not be linked to any data that was identifiable to them. The participants then completed the 24 questions used to 'determine their partner from a previous study'. Once participants had finished responding, they were thanked for their patience and told they would now be matched. The image of the confederate then appeared on screen with either 87% or 17% match (depending on condition) and the participant was told that "Based on your responses to the previous questions you have been matched with this participant" (see Figure 14).

Figure 14: Image of confederate shown to participants after they had been 'matched'

Following 'introduction' to their 'matched' confederate, participants proceeded to the VPT task, adapted from Samson et al., (2010). The design stayed very similar as Studies 1 to 4, other than the 'avatar' being the sole confederate participants had just been 'matched' with.

Following the VPT task, participants were informed that they would be asked some questions regarding their perceptions of their matched partner (the confederate). They were encouraged to answer honestly and assured that their responses would be anonymous and never seen by the confederate. These were the Mind Attribution Scale, Trust Scale and Empathy Quotient in immediate succession. They were then asked to judge Similarity, "How similar did you feel to the person on screen?" by moving an icon along a sliding scale of 0 to 100.

Participants were then debriefed and informed of the deception they had been subject to. They were encouraged to contact the researcher if they had any questions or issues. They were compensated for their time upon receipt of their data.

3.3.2. Results

Analyses

The analytical methods used for this experiment were the same as Study 4.

Accuracy

Mean accuracy scores were analysed using a three-way mixed model ANOVA (see Table 22). There was a significant Consistency effect $F(1,96)= 75.45$, $p <.001$, $\eta p^2 =.44$. Participants were more accurate when their perspective and the confederate's perspective were Consistent (M =.95, SD =.06) compared to Inconsistent (M =.88, SD =.08).

Table 22: Means (and Standard Deviations) for Accuracy in Study 5

	High Similarity	Low Similarity
Own Consistent	.97 (*.06*)	.95 (*.07*)
Own Inconsistent	.87 (*.10*)	.89 (*.11*)
Other Consistent	.94 (*.08*)	.94 (*.07*)
Other Inconsistent	.89 (*.10*)	.85 (*.10*)

There was a significant Perspective x Consistency x Similarity interaction $F(1,96)= 4.67$, $p = .03$, $\eta p^2 =.05$. Paired t-tests showed significant Consistency effects in the Low Similarity conditions when judging from the participants own perspective $t(58)= 4.80$, $p <.001$, $d = -0.81$, and a numerically larger Consistency effect when participants were judging from the confederate's perspective $t(58)= -6.18$, $p <.001$, $d = -0.97$. In the High Similarity conditions there was still a significant Consistency effect when judging from the confederate's perspective $t(38)= 2.97$, $p = .003$, $d = -0.53$. However, there was a larger Consistency effect when judging from the participants own perspective $t(38)= 5.50$, $p <.001$, $d = -1.28$.

There was no significant Perspective effect $F(1,96)= 2.08$, $p = .15$, $\eta p^2 = .02$. There was no significant two way interactions, Perspective x Consistency $F(1,96)= .32$, $p = .58$, $\eta p^2 =.00$, Perspective x Similarity $F(1,96)= .92$, $p = .34$, $\eta p^2 =.01$, Consistency x Similarity $F(1,96)= .01$, $p = .93$, $\eta p^2 =.00$.

Reaction Times

Mean reaction times were also analysed with a three-way mixed model ANOVA (see Table 23). There was a significant effect of Consistency $F(1,96)= 135.57$, $p <.001$, $\eta p^2 = .59$.

When the two perspectives were Consistent participants were much faster to make the correct response (M = 799.44, SD = 147.83) compared to Inconsistent (M = 898.17, SD = 155.35).

Table 23: Means (and Standard Deviations) for Reaction Times in Study 5

	High Similarity (*ms*)	Low Similarity (*ms*)
Own Consistent	839 (*167*)	783 (*144*)
Own Inconsistent	899 (*182*)	864 (*143*)
Other Consistent	800 (*153*)	777 (*152*)
Other Inconsistent	948 (*159*)	882 (*176*)

There was a significant Perspective x Consistency interaction effect $F(1,96)= 12.37$, $p<.001$, $\eta p^2 =.11$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(97)= -6.57$, $p <.001$, $d = 0.67$, and a numerically larger Consistency effect when participants were judging from the confederates perspective $t(96)= -10.31$, $p <.001$, $d = 1.12$,

There were no significant Perspective effect $F(1,96)= .46$, $p =.50$, $\eta p^2 = .01$. Neither of the other two-way interactions were significant, Perspective x Similarity $F(1,96)= .00$, $p = .97$, $\eta p^2 =.00$, Consistency x Similarity $F(1,96)= .36$, $p = .55$, $\eta p^2 = .00$. The Perspective x Consistency x Similarity interaction was not significant $F(1,96)= 3.74$, $p =.06$, $\eta p^2 =.04$, illustrated in Figure 15. Paired t-tests showed significant Consistency effects in the Low Similarity condition when judging from the participants own perspective $t(58)=-6.69$, $p<.001$, $d= 0.87$, and a numerically larger Consistency effect when participants were judging from the confederates perspective $t(58)= -7.13$, $p <.001$, $d = 1.02$. In the High Similarity conditions there was still a significant Consistency effect when judging from the participants own perspective $t(38)= -2.87$, $p= .003$, $d = 0.48$. Further, there was a larger Consistency effect when judging from the confederate's perspective $t(38)= -7.69$, $p <.001$, $d = 1.26$.

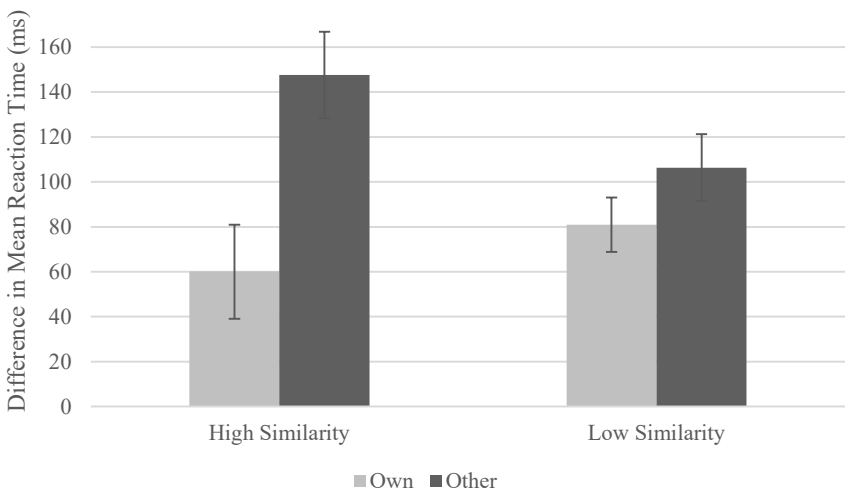


Figure 15: Reaction time Consistency Effects within each Perspective condition for the two Similarity conditions in Study 5.

Additional Measures

Independent samples t-tests were used to investigate the effect of Similarity on ratings of Mind Attribution, Trust, Empathy, and self-reported Similarity (see Table 24). There was no significant difference between self-reported feelings of Trust toward the confederate of the High and Low Similarity conditions t(96)= .05, p = .13, d = -0.01. There was no significant difference between High and Low self-reported ratings of Similarity t(96)= .05, p = .15, d = -0.04. There was also no significant difference from the scores given for the Mind Attribution scale t(96)= -.57, p = .97, d = 0.12 and no significant difference for the Empathy Quotient t(96)= -.86, p = .44, d = 0.18.

Table 24: Means (and Standard Deviations) for Additional Measures in Study 5

	High Similarity	Low Similarity
Similarity	39.05 (*27.13*)	38.17 (*23.01*)
Mind Attribution	4.03 (*.73*)	4.12 (*.79*)
Trust	3.42 (*.37*)	3.42 (*.50*)
Empathy	3.35 (*.58*)	3.45 (*.54*)

3.3.3. Discussion

The aim of Study 5 was to see how manipulating participant's perceptions of Similarity to the confederate would affect their performance on the VPT task. There was no coordination with the confederate in this experiment, any interference effects can be attributed to the Similarity manipulation. Study 4 found that physical similarity resulted in an increase in egocentric intrusions, wherein participants were possibly finding it effortful to take on the perspective of the 'other' rather than project their own mental states. In Study 5 a novel Similarity manipulation was introduced, asking participants a series of demographic questionnaires and telling them that they were to be selectively 'matched' with the confederate either as a High or a Low Similarity pairing. It was expected that when the participants have been explicitly told that the confederate was similar to them, they would infer that this extends to the mental state of the confederate. Physical similarity cues have limits for online research, explicit informational cues were expected to find stronger effects.

The informed High Similarity condition resulted in increased amounts of egocentric intrusions when judging from the other perspective. This supports the hypothesis and the findings of Study 4, where physical or inferred Similarity to the confederate leads to projection of the 'self' rather than taking on the perspective of the 'other'. When assuming high similarity of mental states, participants' perspective taking abilities were limited by their egocentric biases, whereas those who were anticipating low similarity approached the task with a 'difference mind-set' and were more successful. This is further supported by the difference in altercentric intrusions between the High and Low Similarity conditions. Participants in the latter condition experienced more altercentric intrusions, implying that their success in perspective taking also translated to difficulty in ignoring the 'other' perspective. Although it is noted that there was no significant difference in the participants self-reported explicit feelings of Similarity.

From these findings it can be asserted that receiving information of similarity does provide enough social information to affect performance in the VPT task. However, the findings of Studies 4 and 5 do not provide evidence that increased similarity as a result of synchrony alone can function as an explanation for the effect of synchrony on VPT. The factor of interpersonal coordination with the confederate must be included.

3.4. Study 6: Perceived (informed) Similarity and Synchrony

3.4.1. Methodology

Overview

Study 6 provides an initial investigation as to how synchrony might alter the influence of informed perceptions of similarity on VPT. Studies 1 and 2 found that participants who had synchronised with a confederate who then became the perspective taking target (avatar) felt significantly more similar to them than those who had failed to synchronise (asynchrony). This experiment follows Study 5, which tested how informed perceptions of similarity towards the confederate impacted VPT and reintroduces the coordination task of Studies 1 to 3 following the Similarity manipulation. However, in Study 6, the coordination task only featured the synchronous condition.

Participants

A power analysis (carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009)) indicated that to detect a medium effect size for consistency, d=0.5, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 128 would be required for an independent samples t-test. The participants would be divided equally into two conditions, 64 in both. The experiment was advertised on SONA and the University of East Anglia Psychology Paid Panel. Data collection ran between March and July 2023. Due to time and financial restraints, only 49 participants were collected. Following the application of exclusion criteria used in Studies 1 to 5, only 37 were analysed, making the experiment significantly underpowered. The 'High Similarity' group had 17 participants (M*age* =20.53, SD =2.15). The 'Low Similarity' condition had 20 participants (M*age* =20.60, SD = 7.96). Only female participants, aged 18-30, who had not participated in any of the previous studies were eligible. Participants collected through SONA were compensated for their time with course credits and eligible participants collected on UEA Paid Panel were given a £6 Love2Shop voucher.

Design and Materials

The investigation used a between subjects' design. There were two within subject factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. The between subjects' factor was Similarity; High Similarity or Low Similarity.

Participants were randomly assigned to either the High or the Low group after they consented to take part in the experiment. As in Study 5, all participants were subject to deception as to the Similarity condition, which was manipulated whereby all participants were matched to the same confederate but were informed that they were matched according to High Similarity or Low Similarity based on their questionnaire answers.

This Study used the same questionnaires as Study 5 and was also hosted on Gorilla. All participants saw the same confederate for the VPT and Coordination task. The coordination task matched the Synchronous condition of Studies 1 to 3 and as with previous investigations, VPT was measured using a modified version of the Samson et al., (2010) task. Participants were required to fill out the additional measures of three questionnaires and provide a rating on a similarity scale following the conclusion of their tasks. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times).

Procedure

Participants were provided with a consent form and basic study information and given the option to terminate the experiment if they wished. If they provided their consent, they were immediately asked some demographic questions, which assessed if they were eligible to take part in the study (i.e. age, gender and device used to complete the study). The procedure of Similarity questions following the demographic information collection and participant matching were the same as in Study 5.

Following 'introduction' to their 'matched' confederate, participants began the coordination task. Participants were clearly instructed to tap their hand on the flat table in front of them to the beat of the music that they listened to while watching the video that they were shown. They were informed that this task would last up to 3 minutes and that the participant should continue tapping the whole time. Participants then proceeded to the VPT task, adapted from Samson et al., (2010). This task was identical to the version used in Study 5.

Following conclusion of the VPT task, participants were presented with the Mind Attribution Scale, Trust Scale, Empathy Quotient and Similarity rating scale in immediate succession. After this, participants were asked whether they had in fact, tapped their hand for the whole of the coordination task. To ensure their honesty, participants were assured that their answer would not affect whether they received compensation. They could answer 'Yes throughout the whole task', 'Only part of the time' or 'Not at all'.

Participants were then debriefed and informed of the deception that they had been subject to. They were encouraged to contact the researcher if they had any questions or issues. They were compensated for their time upon confirmation that their data had been received.

3.4.2. Results

Analyses

The analyses for this experiment mirrored the analyses for Studies 4 and 5.

Accuracy

To determine the effect of Similarity, Perspective, and Consistency on mean accuracy scores, a 3-way mixed model ANOVA was conducted (see Table 25). There was a significant Consistency effect $F(1,35)= 29.02$, $p <.001$, $\eta p^2 = .45$. Participants were more accurate when the trials were Consistent (M = .94, SD = .07) than Inconsistent (M = .88, SD = .09). There was a significant Perspective effect $F(1,35)= 8.45$, $p= .01$, $\eta p^2 = .20$. Participants were more accurate when judging from their own perspective (M = .93, SD = .09) than judging from the confederates (M = .89, SD = .08).

Table 25: Means (and Standard Deviations) for Accuracy in Study 6

	High Similarity	Low Similarity
Own Consistent	.94 (*.10*)	.95 (*.09*)
Own Inconsistent	.93 (*.08*)	.90 (*.11*)
Other Consistent	.94 (*.06*)	.94 (*.08*)
Other Inconsistent	.84 (*.09*)	.86 (*.12*)

Additionally, there was a significant Perspective x Consistency interaction effect $F(1,35)= 6.55$, $p = .02$, $\eta p^2 = .16$. Paired t tests revealed a significant Consistency effect when judging from the participants perspective $t(36)= 2.16$, $p = .02$, $d = -0.37$ and a numerically larger one from the confederates perspective $t(36)= 5.43$, $p <.001$, $d = -1.92$.

There were no further significant two way interactions, Perspective x Similarity $F(1,35)= 1.11$, $p = .30$, $\eta p^2 = .03$, Consistency x Similarity $F(1,35)= .42$, $p = .52$, $\eta p^2 = .01$ and no significant three way interaction Perspective x Consistency x Similarity $F(1,47)= 1.66$, $p= .21$, $\eta p^2 = .05$.

Reaction Times

Mean reaction times were also analysed with a three-way mixed model ANOVA (see Table 26). There was a significant Consistency effect $F(1,35)= 52.68$, $p<.001$, $\eta p^2 =.60$. Participants were faster to correctly respond when their perspective and the confederate's

perspective were Consistent (M = 783.40, SD = 123.95) compared to Inconsistent (M = 871.04, SD = 124.52). The difference in consistency effects within each perspective per Similarity condition are displayed in Figure 16.

Table 26: Means (and Standard Deviations) for Reaction Times in Study 6

	High Similarity (*ms*)	Low Similarity (*ms*)
Own Consistent	804 (*175*)	780 (*116*)
Own Inconsistent	866 (*149*)	850 (*125*)
Other Consistent	802 (*147*)	748 (*93*)
Other Inconsistent	908 (*157*)	861 (*126*)

There was not a significant Perspective effect $F(1,35)= .10$, $p =.75$, $\eta p^2 = .00$. The Perspective x Consistency interaction was not significant $F(1,35)= 3.61$, $p = .07$, $\eta p^2 = .12$. Although paired t-tests show a significant Consistency effect when judging from their own perspective $t(36)= -4.11$, $p <.001$, $d = 0.66$ and a numerically larger Consistency effect when judging from the confederates' perspective $t(36)=-6.61$, $p<.001$, $d=1.19$. There were no significant two way interactions, Perspective x Similarity $F(1,35)= 1.04$, $p = .31$, $\eta p^2 = .03$, Consistency x Similarity $F(1,35)= .10$, $p = .75$, $\eta p^2 = .00$. There was no significant three way Perspective x Consistency x Similarity interaction $F(1,35)= .00$, $p = 1.00$, $\eta p^2 = .00$.

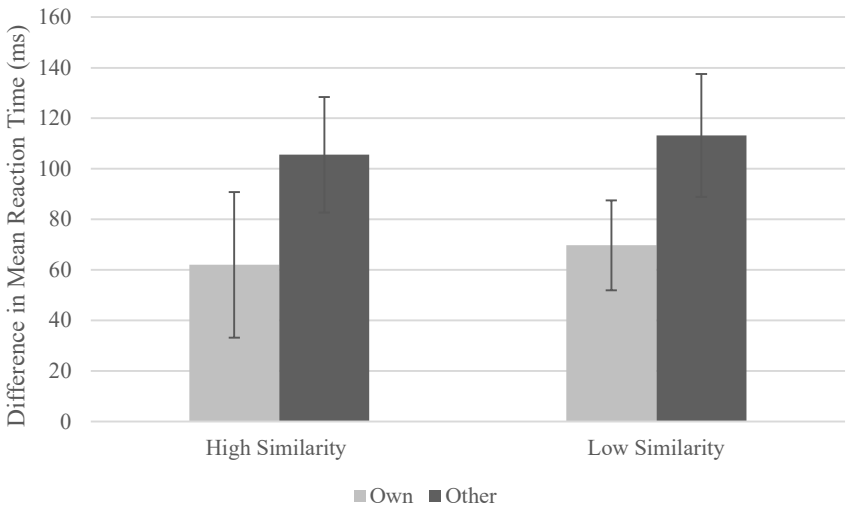


Figure 16: Reaction time Consistency effects within each Perspective conditions for the two Similarity conditions in Study 6

Additional Measures

To determine the effect of the Similarity manipulation on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity an independent samples t-test was conducted. The descriptive statistics are shown in Table 27.

Table 27: Means (and Standard Deviations) for Additional Measures in Study 6

	High Similarity	Low Similarity
Similarity	44.00 (*23.61*)	36.95 (*29.13*)
Mind Attribution	4.24 (*.64*)	3.95 (*.96*)
Trust	3.33 (*.46*)	3.37 (*.50*)
Empathy	3.41 (*.43*)	3.49 (*.46*)

There was no significant difference between High and Low Similarity groups in self-reported ratings of similarity $t(35)= .80$, $p = .21$, $d = -0.26$. There was also no significant difference in Mind Attribution scale responses $t(35)= 1.36$, $p = .25$, $d = -0.36$. Further, no significant difference between perceived Trust of confederates $t(35)= -.27$, $p = .46$, $d = 0.09$ and no significant difference between Empathy ratings $t(35)= -.57$, $p = .65$, $d = 0.19$.

3.4.3. Discussion

Studies 1 to 3 explored how synchrony could influence VPT and Studies 4 to 5 explored how (physical or informed perceptions) similarity might impact VPT. Study 6 sought to test the combination of these social factors, aiming to investigate how manipulated similarity would compute alongside synchrony to impact VPT.

Due to limitations of resources for data collection, Study 6 was significantly underpowered. As a result, no concrete conclusions of how synchrony and Similarity interrelate for VPT performance can be formed. However, some interference effects are observed which tentatively indicate that synchrony does affect how much VPT is influenced by Similarity. In Studies 4 and 5 more egocentric intrusions in the High Similarity conditions were seen which supported the theory that similarity to the confederate will limit perspective taking of the 'other' in favour of projection of the 'self'. Here, similar rates of interference for both High and Low Similarity conditions are noted. In Studies 1 and 2 synchrony was seen to bringing the 'other' perspective closer to the 'self' perspective, which cautiously suggests that synchrony is aiding perspective taking, or reducing egocentric biases through synchronous joint action.

The lack of power in Study 6 means a lack of the evidence necessary to answer the research questions. However, the findings of this study imply that synchrony and similarity as social factors do relate in impacting VPT. The next stage in investigating how synchrony and similarity interfere or support VPT performance, is by the inclusion of a failure to synchronise (asynchrony) as a comparison.

3.5. Study 7: Perceived (informed) Similarity and Coordination

3.5.1. Methodology

Overview

The aim of Study 7 is to expand on the investigation of Study 6 with the further addition of an asynchronous coordination condition. Study 7 investigated how informed perceptions of similarity towards a confederate followed by a synchronous or asynchronous coordination with the same confederate will impact VPT with that same confederate acting as the avatar. Study 7 is novel to the literature for investigating how two social factors will relate to influence VPT.

Participants

Based on findings of Studies 1 to 3, a power analysis (carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009)) indicated that to detect a medium effect size, d=0.5, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 256 would be required with participants divided equally into four conditions for an independent samples t-test. The experiment was advertised on Prolific and data collection ran in August 2023. The participant criteria remained the same as Studies 4 and 5, ensuring the basic demographics of age and gender matched with the confederate and would not impact perceptions of similarity.

256 participants were collected, following application of exclusion criteria, 197 were included in the final analysis. In the 'High Similarity Synchrony' group there were 49 participants (M*age* = 24.45, SD =2.84) and in the 'High Similarity Asynchrony' group there were 52 participants (M*age* = 24.90, SD = 2.93). In the 'Low Similarity Synchrony' group there were 54 participants (M*age* = 24.33, SD =4.55) and in the 'Low Similarity Asynchrony' group there were 42 participants (M*age* = 24.74, SD = 2.76).

Design and Materials

The investigation used mixed design. There were two within subjects' factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. There were two between subjects' factors. The first was Similarity; High Similarity or Low Similarity. The other was Coordination; Synchronous or Asynchronous.

Participants were randomly assigned to one of four condition groups after they consented to take part in the experiment. They were either in High Similarity Synchrony (HSS), High Similarity Asynchrony (HSA), Low Similarity Synchrony (LSS) or Low Similarity

Asynchrony (LSA). As in Study 5 and 6, all participants were subject to deception as to the Similarity condition, which was manipulated whereby all participants were matched to the same confederate but believed they were matched according to High Similarity or Low Similarity based on their questionnaire answers. This phase used the same questionnaires as Studies 5 and 6 and was also hosted on Gorilla.

Participants all saw the same confederate for the VPT and Coordination task. However, there were two videos for the coordination task, The 'Synchrony' video showed the participant tapping at 90bpm with a 90bpm audio track overlay, so that the confederate appeared to be tapping at the same rate as the participants were. For the 'Asynchrony' condition, the participant heard and tapped along to a 90bpm audio track, but the confederate was tapping at a visibly, but not distractingly, faster rate than the participant (110bpm).

As with previous investigations, spontaneous VPT was measured using a modified version of the Samson et al., (2010) task. Participants were required to fill out three questionnaires and provide a rating on a similarity scale following the conclusion of their tasks. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times).

Procedure

Upon agreeing to take part in the experiment, participants are immediately asked to complete a demographic questionnaire. This reiterated the participant requirements from the Prolific advertisement to ensure that the criteria were met. Those eligible proceeded to the main questionnaire, which gathered demographic information about them that, they were informed would be used to match them to a "participant of a previous study". Participants then were shown their 'match' and the manipulated percentage rating of similarity as in Study 5.

Following 'introduction' to their 'matched' confederate, participants began the Coordination task. Here, they were presented with one of two videos depending on which condition they had been grouped into. In all conditions, participants were clearly instructed to tap their hand on the flat table in front of them to the beat of the music that they could hear while watching the video they were shown. They were informed that this task would last up to 3 minutes and that the participant should continue tapping the whole time. Participants then proceeded to the VPT task.

Participants were presented with the Mind Attribution Scale, Trust Scale, Empathy Quotient and Similarity rating scale in immediate succession following conclusion of the VPT task. The final questions asked participants whether they did, in fact, tap their hand for the whole of the Coordination task. To ensure their honesty, participants were assured that their answer would not affect whether they received compensation. They could answer 'Yes throughout the whole task', 'Only part of the time', 'Not at all'. Participants were then debriefed and informed of the deception they had been subject to. They were encouraged to contact the researcher if they had any questions or issues. They were compensated for their time upon confirmation that their data had been received.

3.5.2. Results

Analyses

The analyses for this experiment mirrored the analyses for previous studies. The primary analysis was a 2x2x2x2 mixed-model analysis of variance (ANOVA) with Perspective (Self or Other) and Consistency (Consistent or Inconsistent) as the within-subjects variables and Similarity (Similar or Dissimilar) as Coordination (Synchrony or Asynchrony) as the between-subjects factors.

Accuracy

To determine the effect of Coordination, Similarity, Perspective, and Consistency on mean accuracy rates, a 4-way mixed model ANOVA was conducted (See Table 28). There was a significant Consistency Effect $F(1,193)= 221.39$, $p <.001$, $\eta p^2 = .53$. Participants were more accurate on Consistent trials (M = .96, SD = .06) than Inconsistent trials (M = .89, SD = .07).

Table 28: Means (and Standard Deviations) for Accuracy in Study 7

Coordination		High Similarity	Low Similarity
Synchrony	Own Consistent	.96 (*.07*)	.95 (*.09*)
	Own Inconsistent	.89 (*.11*)	.91 (*.09*)
	Other Consistent	.96 (*.07*)	.96 (*.06*)
	Other Inconsistent	.90 (*.10*)	.85 (*.10*)
Asynchrony	Own Consistent	.96 (*.06*)	.96 (*.07*)
	Own Inconsistent	.89 (*.09*)	.90 (*.10*)
	Other Consistent	.94 (*.08*)	.95 (*.07*)
	Other Inconsistent	.89 (*.11*)	.90 (*.10*)

There was a significant Perspective x Consistency x Similarity interaction $F(1,193)= 4.53$, $p = .04$, $\eta p^2 = .02$. Paired t-tests showed that for the High Similarity condition there was a significant Consistency effect when judging from the participants own perspective $t(100)= 7.97$, $p <.001$, $d= -1.05$ and a numerically smaller Consistency effect when judging from the confederates perspective $t(100)=5.93$, $p <.001$, $d = -0.70$. Whereas from the Low Similarity condition, there was a significant Consistency effect when judging from the participants own

perspective $t(95)= 4.69$, $p <.001$, $d= -0.52$ but a numerically larger Consistency effect from the confederates perspective $t(95)= 7.91$, $p <.001$, $d = -1.07$.

Further, there was a significant Perspective x Consistency x Coordination interaction $F(1,193)= 4.26$, $p = .04$, $\eta p^2 = .02$. Paired t-tests revealed that within the Synchrony coordination group there was a significant Consistency effect when judging from the participants own perspective $t(102)= 5.92$, $p <.001$, $d = -0.64$ and a numerically larger one from the confederates perspective $t(102)= 8.72$, $p <.001$, $d = -1.12$. Within the Asynchronous Coordination group, there was a significant Consistency effect when judging from the participants own perspective $t(93)= 6.57$, $p <.001$, $d = -0.89$ but a numerically smaller Consistency effect when judging from the confederates perspective $t(93)= 5.11$, $p <.001$, $d = -0.64$.

There was no significant effect of Perspective $F(1,193)= 2.41$, $p = .12$, $\eta p^2 = .01$. There were no significant two way interactions Perspective x Consistency $F(1,193)= .09$, $p = .76$, $\eta p^2 = .00$, Consistency x Coordination $F(1,193)= 2.04$, $p = .16$, $\eta p^2 = .01$, Consistency x Similarity $F(1,193)= .07$, $p = .79$, $\eta p^2 = .00$, Perspective x Coordination $F(1,193)= .01$, $p = .93$, $\eta p^2 = .00$, Perspective x Similarity $F(1,193)= 1.07$, $p = .30$, $\eta p^2 = .01$.

Reaction Times

A four-way ANOVA was performed to analyse the effect of Coordination (Synchrony or Asynchrony), Similarity (High or Low), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) on reaction times (see Table 29).

Table 29: Means (and Standard Deviations) for Reaction Times in Study 7

Coordination		High Similarity (*ms*)	Low Similarity (*ms*)
Synchrony	Own Consistent	742 (*150*)	731 (*142*)
	Own Inconsistent	812 (*177*)	815 (*158*)
	Other Consistent	726 (*160*)	716 (*133*)
	Other Inconsistent	822 (*155*)	834 (*168*)
Asynchrony	Own Consistent	729 (*155*)	744 (*148*)
	Own Inconsistent	787 (*138*)	830 (*140*)
	Other Consistent	725 (*164*)	752 (*133*)
	Other Inconsistent	806 (*162*)	882 (*157*)

There was a significant Consistency effect $F(1,193)= 329.95$, $p <.001$, $\eta p^2 = .63$. Participants were faster to respond correctly on Consistent trials (M = 773.12, SD = 142.34) than Inconsistent trials (M = 823.48, SD = 148.16). There was also a significant Consistency x Similarity interaction $F(1,193)= 8.30$, $p = .004$, $\eta p^2 = .04$. There was a larger difference between Consistent (M = 735.66, SD = 142.81) and Inconsistent (M= 840.35, SD = 148.64) in Low Similarity conditions than between Consistent (M = 730.58, SD = 141.75) and Inconsistent (M= 806.60, SD = 147.54) in High Similarity conditions.

Further, there was a significant Perspective x Consistency interaction $F(1,193)= 11.26$, $p <.001$, $\eta p^2 =.06$. Paired t-tests show that there was a significant Consistency effect when judging from the participants own perspective $t(196)= -10.36$, $p <.001$, $d = 0.78$ and a numerically larger one from the confederates perspective $t(196)= 15.81$, $p <.001$, $d = 1.19$. The difference in consistency effects within each perspective per Similarity and Coordination condition are displayed in Figure 17.

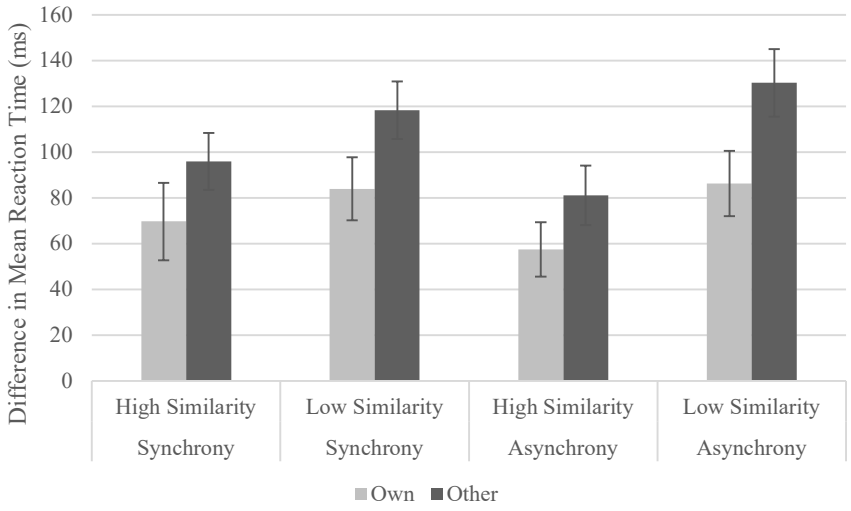


Figure 17: Reaction time Consistency Effects within each Perspective condition for the four Coordination and Similarity conditions in Study 7.

There is no significant effect of Perspective $F(1,193)= 2.87$, $p = .09$, $\eta p^2 = .02$. Also no further significant two way interactions, Consistency x Coordination $F(1,193)= .10$, $p = .75$, $\eta p^2 = .00$, Perspective x Coordination $F(1,193)= 3.18$, $p = .08$, $\eta p^2 = .02$, Perspective x Similarity $F(1,193)= 1.48$, $p = .23$, $\eta p^2 = .01$. There were no significant three-way interactions, Perspective x Consistency x Coordination $F(1,193)= .03$, $p = .85$, $\eta p^2 = .00$, Perspective x

Consistency x Similarity $F(1,193)= .56$, $p = .46$, $\eta p^2 = .00$, Perspective x Similarity x Coordination $F(1,193)= .63$, $p = .43$, $\eta p^2 = .00$, Consistency x Similarity x Coordination $F(1,193)= 1.08$, $p = .30$, $\eta p^2 = .01$.

Additional Measures

To determine the effect of the Similarity manipulation between Coordination conditions on the additional self-report measures of Mind Attribution, Trust, Empathy and similarity, a split independent samples t-test was conducted. The descriptive statistics are shown in Table 30.

Table 30: Means (and Standard Deviations) for Additional Measures in Study 7

Coordination		High Similarity	Low Similarity
Synchrony	Similarity	50.92 (*22.10*)	41.55 (*23.91*)
	Mind Attribution	4.35 (*.56*)	4.14 (*.68*)
	Trust	3.50 (*.43*)	3.39 (*.47*)
	Empathy	3.40 *(.56*)	3.37 (*.54*)
Asynchrony	Similarity	52.10 (*21.54*)	44.00 (*20.82*)
	Mind Attribution	4.16 (*.59*)	4.05 (*.69*)
	Trust	3.47 (*.47*)	3.37 (*.41*)
	Empathy	3.50 (*.49*)	3.37 (*.43*)

Synchrony

There was no significant difference between High and Low Similarity groups in self-reported ratings of Similarity $t(100)= 2.05$, $p = .18$, $d = -0.41$. Nor was there any significant difference in Mind Attribution scale responses $t(100)= 1.64$, $p = .43$, $d = -0.33$ or any significant difference between perceived Trust of confederates $t(100)= 1.27$, $p = .70$, $d = -0.25$. There was also no significant difference between Empathy ratings $t(100)= .26$, $p = .61$, $d = -0.05$.

Asynchrony

There was no significant difference between High and Low Similarity groups in self-reported ratings of Similarity $t(91)= 1.82$, $p = .92$, $d = -0.38$. Further, there was no significant difference in Mind Attribution scale responses $t(91)= .82$, $p= .41$, $d = -0.17$. There was also no significant difference between perceived Trust of confederates $t(91)= 1.09$, $p = .67$, $d = -0.23$ or between Empathy ratings $t(91)= 1.35$, $p = .52$, $d = -0.28$.

3.5.3. Discussion

The aim of Study 7 was to investigate how the social factor of informed perception of similarity would interact with the social factor of synchronising or failing to synchronise (asynchrony) to influence VPT of the confederate. Studies 4 and 5 indicated that physical or informed perception of similarity to the confederate led the participant to be limited by their own egocentric biases. Suggesting that rather than taking on the 'other' perspective they instead projected their 'self' knowledge. Studies 1 to 3 found that synchrony seemed to facilitate perspective taking, possibly through bringing the self and other mental representations closer. In Study 6, there was indication that the addition of synchrony with the confederate would change the effects of similarity on the VPT task. In Study 7, the relationship between synchrony and similarity on VPT was further explored.

This research expands the literature by testing the influence of the two social factors on VPT. The findings of Study 7 are that a coordinated interaction will interfere with the effect of perceived similarity on VPT, however the intricacies of this relationship are unclear. All interpretive theories are speculative, it does appear that engagement in the coordination task had influence, not specifically motor synchrony. It does appear that the High Similarity conditions in Study 7 seem closer to the effects of synchrony on VPT in Studies 1 and 2 in terms of interference, with reduced egocentric but increased altercentric intrusions. However, the effects in the Low Similarity conditions indicate possible participant confusion. When participants had been told that the confederate did not have a similar mental state to themselves but then engaged in the motor task with the confederate, the participant had more uncertainty when judging between perspectives.

The conclusions of Study 7 do not indicate whether coordination is a stronger influence than synchrony or vice versa. Instead, it appears that the Similarity manipulation and motor Coordination task information must be internally balanced by the participant. The participants are receiving a large amount of social information about the confederate which attempted to inform their perceptions of them and influence their ability to separate their 'self' perspective from the 'other' perspective. Whilst the addition of a motor coordination interaction did change how Similarity cues influence VPT, further research is needed to explore how.

3.6. Chapter Discussion

The aim of this chapter was to investigate how perceptions of similarity might impact Level-1 visual perspective taking (VPT) and to explore the influence of synchrony on these perceptions and outcomes of similarity. Specifically, we sought to test whether similarity of the participant to the confederate could explain the pattern of results found in Studies 1 to 3. To this end, two dimensions of similarity were investigated to consider the influence of both the embodiment (Study 4) and mentalising (Study 5) accounts on VPT. The latter was then pursued in two further studies (Studies 6 and 7) with the re-introduction of the coordination task of Studies 1 to 3 following the informed perceptions of Similarity manipulation, to see how combining the two social factors would impact VPT.

Influence of Similarity on Visual Perspective Taking

Studies 4 and 5 investigated two different dimensions of similarity and the subsequent effects on visual perspective taking. Based on the literature it was theorised that if the participant considered the confederate as similar to themselves, the 'starting point' for perspective taking would change. The findings indicate that similarity to someone, whether acknowledged or not, changes our mental foundation for perspective taking by inhibiting it. Both Studies 4 and 5 found inconsistency effects with participants slower and less accurate in either perspective judgement if the two perspectives were inconsistent. Moreover, both found that having explicit or implicit cues of High Similarity with the avatar increases egocentric intrusions. Further, the levels of interference following Low Similarity cues between Studies 4 and 5 appear alike. It appears that participants were better prepared to take on the 'other' perspective when they approached with a mind-set of difference, cued by the (dis)similarity manipulation. Both egocentric and altercentric intrusions were still experienced, but for participants receiving Low Similarity cues, VPT was not limited by egocentric biases to the 'self'.

The findings of Study 4 both supports and challenges prior research of how an 'in-group' avatar might impact VPT by testing the cue of physical similarity (same or different race) to the white participant. Like Simpson and Todd (2017), there were more egocentric intrusions for an in-group, high similarity avatar. However, as stated in the Study 4 discussion, this contrasts the findings of Valerjev & Dujmović (2017) who investigated the influence of the skin colour effect on VPT using a 3D avatar and found no differences in interference effects. By using a real confederate as the avatar in a real room in Study 4, participants were possibly

better able to recognise and process the social information provided by the physical similarity cues and which informed their perspective taking. The similar levels of altercentric intrusions between the two conditions suggest that whilst there were egocentric biases, the VPT task was sufficiently straightforward that embodiment of the confederate could occur.

Study 5 primarily supports the account for mentalising of similarity affecting perspective taking. The manipulation of perceived (informed) similarity required participants to answer a lengthy questionnaire about themselves, which asked briefly about their lives, relationships, skills, health, education and opinions. This encouraged participants to consider and focus on their own mental states prior to experiencing the effects of the Similarity manipulation on their mental representation of the confederate. If they were told the confederate was dissimilar, they approached the VPT task with a mindset of difference between themselves and the confederate and performed more successfully, as suggested would be the case by Todd, Hanko, Galinsky and Mussweiler (2011). The participants who were told the confederate was similar to themselves experienced the most difficulty in taking on the 'other' perspective, limited by projections of their 'self' perspective onto the perspective taking target, which had been encouraged by the experimental manipulation.

Perceiving someone as different either by using physical cues or by being directly informed that they have different mental states both caused participants to approach perspective taking with a distinct separation of 'self' and 'other' mental representations. This is expressed in the relatively equivalent level of reaction time interference effects for Low Similarity conditions in Studies 4 and 5. However, the High Similarity group for Study 5 showed greater difference between altercentric and egocentric intrusions than the condition in Study 4. VPT necessitates separating our own visual experience from that of the target, in this case the confederate. To what extent cues of physical similarity can inform our 'other' mental representations is down to individual, self-imposed limits. Whereas being told someone has similar answers to ours, about life, hobbies and education, appears to be giving a wealth of data to inform your knowledge of their mental states despite technically being your own self-knowledge. When you have already been thinking about your internal representation of 'self' it is at the forefront of your mind. It is then challenging to not project onto the 'other'. Physical cues of similarity affect perspective taking but informed perceptions of similar mental states impose greater limits on forming mental representations of others.

Interference of Synchrony and Similarity

Increased perceptions of similarity with someone are an established outcome of engaging in synchronous movement with them (Rabinowitch & Knafo-Noam, 2015; Valdesolo & DeSteno, 2011). This effect was found in Studies 1 and 2 of this investigation. Further, being engaged synchronously with another appears to change our mental representations of 'self' and 'other' as synchrony brings the representations closer together, even merging them to the point where people might confuse someone else's face for their own (Tsakiris, 2008). This was thought to be true of inanimate 'others' as well, but more recent research into the rubber hand illusion has found that synchrony induced illusions of ownership might be more strongly influenced by perceived agency than perceived similarity (Ma & Hommel, 2015). Therefore, whilst literature on similarity as an outcome of synchrony is extensive, how synchrony might change established perceptions of similarity has not been considered. The previous studies reported here, have so far have evidenced that synchrony (Studies 1 to 3) and similarity (Studies 4 and 5) would impact VPT as independent social factors. In Studies 6 and 7, the coordination task was reintroduced to the experimental design to see how a combination of social factors would impact cognitive processing of VPT.

In both Studies 6 and 7, the expected inconsistency effects were found and the extent to which these inconsistency effects were observed was impacted by the prior social knowledge of the target. As stated earlier, the process of manipulating perceived similarity encouraged the participants to have their 'self' mental representation prioritised before engagement in the VPT task which increased egocentric biases and intrusions. The re-introduction of motor coordination task distinguishes the confederate as a separate individual to the participant, anticipated to facilitate consideration of the 'other' mental states. In Study 6, this appears to be the case with the intrusion effects for both conditions resembling the synchrony condition of Study 2. However, Study 6 was significantly underpowered. Study 7 was a better exploration into how similarity and coordination will interact, which appears to be greater uncertainty in perspective taking.

Expectations of similarity to the confederate leads the participant to unconsciously project their internal, egocentric self-representation. Expectations of dissimilarity keep the 'self' and 'other' more distinct. However, participants then receive information that complements or contrasts this. Synchrony leads to feelings of similarity, by way of bringing the 'self' and 'other' representations closer together, fostering social connection. Failing to

synchronise (asynchrony) distances the 'other' from the participants self-representation. The combination of these social factors appears to confuse participants by signalling differing cues for internal representations of 'self' and 'other' which then creates more interference within the cognitive mechanisms, including VPT. It seems that assumption of similarity is benefitted by engagement in motor coordination, regardless of synchrony or asynchrony, as it improves perspective taking rather than projecting the 'self' mental states. In contrast, assumption of dissimilarity under the same conditions appears to create uncertainty. Future research should investigate further how complementary or opposing social information can influence perspective taking.

Chapter 3 concludes that manipulated perceptions of similarity are not a sufficient explanation for the impact of synchrony on VPT found in Studies 1 to 3. As in the rubber hand illusion, similarity with the target might help with merging the 'self' and 'other', but it is not a functional requirement. Synchrony seems to bring our mental representations of 'self' and 'other' closer together, which does result in perceptions of similarity, but initial separation of the mental representations is a pre-requisite for this effect.

The findings of Studies 5 to 7 do further evidence that prior social knowledge of the avatar will influence VPT abilities. As perspective taking relies on our self-knowledge and understanding of our mental states, awareness of differences between ourselves and others inhibits us from projecting our own perspective and assuming it is the other persons. When you know more about the other person, the unconscious process of taking on their visual perspective becomes more complex but not necessarily more difficult.

The final note to be considered is that Studies 4 to 7 did not report any significant differences between conditions in self-reported similarity. Differences in intrusion effects between Coordination and (Physical and informed Perception) Similarity conditions were found, but evidently, the participants were unaware that their cognitive processing was affected by the social information manipulations. The additional measure of similarity included in this investigation asked participants, at the very end of the study, to move a marker on a sliding scale to rate how similar they felt to the person on screen. This approach was sufficient for the studies in Chapter 2, but here it was insufficient to assess the participants own opinion of similarity leading to neutral responses.

Chapter 4

Prediction and Visual Perspective Taking

4.1. Introduction

In Chapter 2 it was found that synchronising, and failing to synchronise (asynchrony), with a confederate would impact a participant's ability to take on the confederate's visual perspective. Synchrony led the participant to experience fewer egocentric intrusions and sometimes greater altercentric intrusions, implying that synchrony caused the participant to bring their mental representations of 'self' and 'other' closer together. Study 3 confirmed that failing to synchronise (asynchrony) also had an effect on VPT abilities compared to a Control condition. Asynchronous coordination appears to result in the participant prioritising their 'self' mental representation by creating a distinctly separate mental representation of the 'other' and using it to inform their VPT judgements. Two possible explanations for the effects observed in Chapter 2 were investigated. Chapter 3 concluded that synchrony increasing perceptions of similarity was a valid outcome but not an explanation for the effects of synchrony on VPT. In this Chapter, the potential explanation of prediction is explored through Studies 8 and 9, which investigate the contributions of predictability of the interaction partner (confederate) to the effects on VPT observed earlier.

4.1.1. Prediction and Coordination

Interpersonal coordination is at the core of human communication, with the ability to temporally adapt at its core. For example, to have a successful conversation with another person, you need to take turns to listen and to speak, which you coordinate by adapting to information such as the speed of talking, the lengths of pauses to know what indicates the other person has finished so you can proceed to speak as well as the tone of the discussion. This is therefore assumed to be a fairly low-level cognitive mechanism, as it occurs automatically and unconsciously (Konvalinka, Vuust, Roepstorff, & Frith, 2010; Keller, 2008). We adapt our behaviours; speech patterns, actions and attention, to the rhythms of the other person to create a fluid and successful social interaction, without being consciously aware of this being our intent. Different rhythms converge into coordination patterns in time, which is due to co-regulation of actions responding to the rhythms produced by other sources be it another person or a metronome. These coordinated actions spontaneously engage into stable synchronisation through entrainment (Phillips-Silver, Aktipis, & Bryant, 2010). Humans are the only known species where both sexes are able to engage in entrainment to an external rhythm, spontaneous synchronisation of movements to rhythmic auditory cues (Patel A. D., 2006). Reportedly, there is an association between rhythmic auditory cues and motor behaviour, visual rhythm cues do

not yield similar results (Patel, Iversen, Bregman, Schulz, & Schulz, 2008). However, in *social* entrainment the presence of another person becomes the stronger rhythmic cue. Rosso, Maes and Leman (2021) found that if two individuals engaged in action perceived each other, their rhythms became 'attracted' to each other. Coupling of visual and auditory information led to spontaneous dyadic entrainment even when participants were explicitly told to synchronise to their assigned metronome. This investigation has utilised how interpersonal perceptions will affect participants interpretation of their own sensorimotor entrainment. Tapping to music which never coordinates to the confederate is perceived by the subject as a failure to synchronise despite technical successful synchrony to the auditory cues.

Coordinating our behaviours with others requires us to be able to understand the behaviours of others, to use that understanding to inform our predictions of their future behaviours and actions, and to integrate that into plans for our own actions so that our behaviours will align with theirs. This is done within milliseconds for the action alignment to occur synchronously. This investigation has ensured this temporal accuracy by the inclusion of an external auditory cue that acts as a rhythmic commonality between the participant and confederate. However, this cue does not remove the need for prediction. We anticipate others to process the external auditory cue the same way that we do to inform our actions and therefore predict that the other person will move to the auditory cue the same way that we move to it. Consequently, sensorimotor synchrony becomes interpersonal synchrony.

Prediction is essential for navigating the world around us. We are unconsciously but constantly generating predictions about the world. Humans are inherently social; therefore our predictions also apply to what others are likely to say or do in the future (Clark, 2013). These predictions are not static, they are constantly being adapted and updated based on new perceptual information received and error corrections. Predictions are made and adjusted with rapidity. This makes us able to have responses prepared in advance to help us achieve our goal, even if that goal is to make polite small talk with someone. These predictions underly all of our behaviours. In the Internal Forward model for action, our brains prepare for a motor behaviour by considering many possible action effects and generating a prediction of the best path to goal achievement. Perceptions and plans for action are integrated into a shared representation which facilitates future behavioural predictions (Prinz, 1997). Action production and action perception use shared neural resources and are coupled to execute successful social interactions (Keller, Novembre, & Hove, 2014). Further, motor predictions have been suggested to be reliant on simulation of the observed action in the same brain areas that are involved in the

generation of that action (Rizzolatti, 2005). As such, to best make accurate action predictions, we need the motor skills necessary to perform the action ourselves, which enables this internal motor simulation (Stapel, Hunnius, Meyer, & Bekkering, 2016).

Our internal models for action-effect predictions are utilised to predict the behaviours of others (Wolpert, Doya, & Kawato, 2003). In cases of joint action, predictive models can be integrated into a shared representation of action and effect. As stated earlier, we automatically entrain to the behaviours of others. However, it has also been theorised that implicit alignment of behaviours may also produce alignment of cognitions (Pezzulo, 2011). Shared representations can both determine own actions and predict the action of the other person, allowing for coordination of behaviour. Coordination is indication of reliable predictions of the other person, which provides positive perceptual information to inform future behaviour coordinations with them and other people. The most successful use of shared representation would thus be synchronising, wherein action and prediction are able to occur concurrently. However, being unable to predict an 'other' is indication that the internal representations of the interactants are not aligned, which may impact coordination and consequently communication.

4.1.2. Prediction within a social context

Interpersonal coordination relies on the ability to switch in and out of synchronisation (Mayo & Gordon, 2020). Within a social context, it is necessary to perform rhythmic behaviours that synchronise with others and non-rhythmic behaviours which might complement or imitate the actions of another (Repp & Su, 2013; Sebanz, Bekkering, & Knoblich, 2006). Interpersonal synchrony utilises oscillations in a way similar to metronomes and is underpinned by self-organisation systems (Howard, Ropar, Newport, & Tunçgenç, 2021). Consequently, interpersonal motor synchrony can be maintained without perceptual information of the other interactants for around 7 seconds (Bardy, et al., 2020).

There are three essential elements required to successfully synchronize with even just one other person. First, you must have the compatible capabilities to engage in coordination. Second, you must be able to form an internal representation of the mental states of the 'other'. Finally, you must have a shared perception of timing. The latter two factors construct the core of coordination, which is that all interpersonal coordination requires the ability to predict the behaviour of the other person(s) involved. Humans are best at predicting the movement of other humans (Stapel, Hunnius, Meyer, & Bekkering, 2016). When in a social context, we have two simultaneous interpersonal adaptative behaviours; being able to synchronise with another

person and being able to stop and start that coordination (Mayo & Gordon, 2020). To do this, our brains require us to simultaneously generate representations of 'self' and 'other' mental states and predict behaviours and to integrate those representations with real time accuracy (Keller, Novembre, & Hove, 2014). Newman-Norlund et al., (2007) found that the actions of one person evoked stronger motor responses in an observer if they intended to interact with, rather than mimic, that person. This highlights the importance of 'self' and 'other' distinction to allow for coordination.

Sacheli, Arcangeli, Carioti, Butterfill and Berlingeri (2022) evidenced that the level of interaction within a social context will affect the involvement of different cognitive abilities such as perspective taking and sensorimotor action predictive mechanisms. They found that presence of a shared goal made action prediction a vital requirement in interpersonal coordination whereas perspective taking has a necessary role in assessing the behaviour of others, regardless of social context. Perspective taking is essential to form our predictions of the other person even to the level of conversational turn-taking. It provides the information of the 'other' which is then integrated into our action predictions. If our predictions prove erroneous it might therefore be expected that the information feeds back and impacts our perspective taking processes.

Interpersonal coordination is strategic. We are motivated to engage in synchrony and other joint actions by shared goals and need for social bonding. Research into joint action has shown that when interactants have shared goals of the action and are aware of this, their intents and attention are united and mental representations of 'self' and 'other' are aligned for the duration of the task (Tomasello, Carpenter, Call, Behne, & Moll, 2005). To coordinate with others, we need to make our own behaviours predictable to the other people and simultaneously gather perceptual information to inform and error correct our predictions of them. Consequently, people will implicitly 'meet each other halfway' by behaving more predictably than they would if they were moving alone. Participants have been found to reduce the variability of their movements when needing to coordinate key presses or hop with a partner (Vesper, van der Wel, Knoblich, & Sebanz, 2011; Vesper, van der Wel, Knoblich, & Sebanz, 2013). We also develop this ability early in our lives. Children of all ages synchronised their drumming with higher accuracy when drumming alongside a social partner (Kirschner & Tomasello, 2010). Shared mental representations of behavioural goals enable prediction of the behaviour of other interactants which, when integrated with own actions, makes coordination of behaviour possible (Sebanz, Bekkering, & Knoblich, 2006). Synchronisation is easier to

achieve with simultaneous sensorimotor coupling and shared mental representations. High behavioural entrainment is associated with integration of 'self' and 'other' whereas low behavioural entrainment fosters reliance on self-knowledge rather than prediction and integration (Novembre, Sammler, & Keller, 2016).

4.1.3. Asynchrony

In order to understand the complexities of prediction, it is crucial to examine the conditions of asynchrony. Small incidences of asynchrony during synchronization tasks are inevitable. It is a consequence of the temporal variability within and between motor and perceptual processes (Repp, 2005). Participants anticipate the occurrence of events rather than merely reacting to the auditory cue. This is essential to be able to perform the action in synchrony with the auditory cue. Keller and Appel (2010) found that trained musicians typically have asynchronies of 30-50ms between tones which were intended to be played in unison. However, these asynchronies are only occurring due to the delay between intention and action. The detection and correction of small asynchronies must be facilitated by automatic motor processing skills. This requires conscious awareness that a small asynchrony has occurred and there appears to be a discrepancy between perceptions of synchronization to a beat and the reality (Matthews, Witek, Thibodeau, Vuust, & Penhune, 2022). Therefore, in research, asynchronies have had to be blatant and undeniable. In this investigation, the asynchronous coordination conditions have been defined as unpredictable asynchrony.

Spontaneous temporal adaptation is a key mechanism in joint action tasks (Lelonkiewicz & Gambi, 2016). However, temporal prediction abilities are subject to individual differences, and these factor in synchronising with another person. Pecenka and Keller (2011) found that High predicting dyads had better accuracy and less variability than Low predicting dyads and dyads of mixed abilities performed intermediately. This research also provides strong evidence that participants can maintain tapping along to a gradually changing auditory cue, that we are able to predict and track simultaneously. However, temporal adaptation abilities are typically dependent on available perceptual information. If synchronising to an arhythmic beat with another person, it is not optimal to continue 'meeting each other halfway' and focusing on shared representations. Instead, a leader-follower interaction can develop (Konvalinka, et al., 2014). One person takes on the role of the leader, focusing on maintaining their own rhythmic action. The other person becomes a follower, prioritising adaptation to the leader and synchrony rather than the rhythm. This becomes

primarily a one-way flow of information, from leader to follower. But the leaders' behaviours are still influenced by temporal features of follower's responses (Lelonkiewicz & Gambi, 2016). Although this interaction would still be considered synchronous, as both interactants are synchronising with a 'cue' it is merely that these cues are different. If the discrepancies were brought to conscious awareness, then the participants may have to return to use of mental 'self' and 'other' representations.

4.1.4. Overview

In this Chapter, the influence of predictable and unpredictable variations of interpersonal coordination (synchrony and asynchrony) on VPT is explored. Manipulating participants perceptions of the predictability of their interaction partners is expected to influence the interference effects shown in the modified VPT task. In Studies 1 to 3 of this investigation, synchrony appears to bring the perspectives of self and other closer together, making it easier to ignore own perspective but more difficult to disregard the visual experience of the 'other'. Synchrony necessitates prediction of the other person, which facilitates integrating internal representations of 'self' and 'other'. In Study 8, predictable and unpredictable synchrony are contrasted to investigate how removal of predictive shared representations will influence VPT. In Study 9, predictable forms of asynchrony are compared with synchrony and with failure to synchronise. It is theorised that leader and follower asynchronous coordination would lead to prioritisation of one perspective over the other. By investigating predictiveness within coordination, this Chapter also seeks to address the gap in knowledge surrounding the role of prediction in the social cognitive effects of synchrony.

4.2. Study 8

4.2.1. Methodology

Overview

The aim of this study is to investigate the and compare the effects of classic, in-phase predictable synchrony and unpredictable in-phase synchrony on VPT. The expectation of this research is that predictable synchrony will generate similar responses to Studies 1 to 3, whilst it is unknown how unpredictable synchrony will be processed by the participant. We theorise that unpredictable synchrony within the coordination task could be perceived as more difficult or 'active' by the participant, as it will be their role to coordinate with the confederate and that this will translate into greater interference effects in the VPT task.

Participants

A power analysis (carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009)) indicated that to detect a medium effect size, d=0.5, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 128 would be required, with 64 in each condition for an independent samples t-test. The experiment was advertised on Prolific and data collection ran in June 2023. Participants were matched to confederates by gender and to prevent possible biases of age, the eligibility limits of 18-30 remained. 128 participants were collected. However, following exclusion criteria, the data from 75 participants were used. In the Predictable Synchrony condition there were 39 participants (M*age* =25.59, SD = 2.91), 20 identifying as male and 4 were left-handed. In the Unpredictable Synchrony condition there were 36 participants (M*age* =26.39, SD =2.75), 18 were male and 6 were left-handed.

Design and Materials

The investigation used a between subjects' design. There were two within subject factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. The between subjects' factor was Predictability: Predictable Synchrony and Unpredictable Synchrony. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times). As with previous investigations, Spontaneous VPT was measured using a modified version of the Samson et al., (2010) task, and participants were required to fill out three questionnaires and provide a rating on a similarity scale following the conclusion of their tasks.

Participants were grouped by Coordination condition. This was controlled by an interaction task with a confederate that matched one of the coordination conditions. There were two confederate partners that participants could be paired with, one male and one female. The background of the two confederates were standardised to be a neutral laboratory setting and they were dressed in neutral casual clothes. For the VPT task, each confederate had 22 images in profile with differing numbers of discs on either side of them (11 facing right, 11 left). All were created by the researcher and the pictures of the confederate were taken at the same time as the videos.

For the Coordination task, each confederate had 2 videos recorded. A 16 second example video for each confederate was also created from a sample of the Predictable Synchrony videos (see Figure 18). As part of their instruction, the participants were shown a short 'example' video. This example video, featuring a confederate partner of the opposite gender to the participant featured audio overlay which matched the audio track the confederates were tapping to. The audio was overlaid for sound quality and to remove any additional noises such as the confederates own hand taps.

Figure 18: Screenshot from the coordination task with male confederate

In contrast to the music with a clear beat used in Studies 1 to 7, the audio track was a repetitive sound series. The pattern comprised of two drumbeats and 'ding' which were spaced 0.5 seconds apart from each other. The time interval between each pattern depended on the

condition (see Figure 19, where the arrows labelled ‘P’ and ‘C’ mark when the participant and confederate respectively tap). In the Predictable Synchrony condition the next drumbeat pattern commenced one second after the previous ‘ding’. In the Unpredictable Synchrony condition, the time between the previous ‘ding’ and next drumbeat varied. The time increased and decreased by 200ms at random intervals so that no rhythmic patterns could be established.

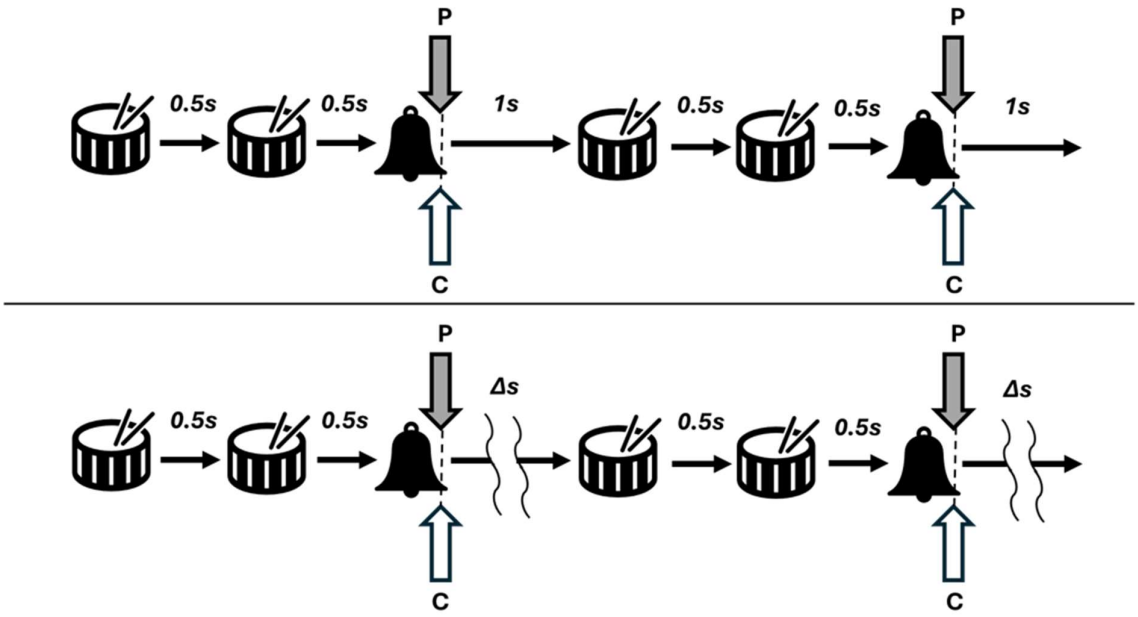


Figure 19: Visual depiction of the auditory stimuli in Study 8; Predictable and Unpredictable Synchrony

Procedure

Participants had to run a brief audio test to ensure the participant had the technology and settings required for the audio-visual components. Once the test concluded, they were presented with the consent form. If they consented, they were asked the standard demographic questions that are used for the other studies in this thesis. Participants were then randomly assigned to one of the Coordination conditions.

The first task of the experiment was the coordination task. In all conditions the participants were clearly instructed to tap their hand on the flat table in front of them when they heard the ‘ding’ while watching the video on the screen. The ‘ding’ sound which was preceded by two ‘warning’ drumbeats so the participants could tap on cue. To ensure complete understanding, participants were shown the 16 second example clip of the other-gendered

confederate tapping on the ‘ding’ cue and given the option to rewatch the clip if they still did not understand. Once the participant had clicked that they were ready for the task, they were informed that it would last up to 3 minutes and that they should continue tapping on the ‘ding’ until the conclusion of the video and audio track.

Following the Coordination task participants were presented with the instructions for the modified VPT task. This matched the task for Studies 1 to 7 of this investigation in which the confederates were used as perspective taking targets (avatars). Upon conclusion of the VPT task, participants were asked to complete a questionnaire on their perceptions of the person that they had just seen (the confederate). They were given the Mind Attribution Scale, Trust Scale and Empathy Quotient questionnaires in immediate succession concluding with indicating on a sliding scale how similar they felt to the confederate. The final questions asked participants whether they did, in fact, tap their hand to the ‘ding’ for the whole of the Coordination task. To ensure their honesty, participants were assured that their answer would not affect whether they received compensation. Participants were also asked if, during the coordination task, they believed that the other person was listening to the same music that they were. Participants were then debriefed and encouraged to contact the researcher if they had any questions.

4.2.2. Results

Analyses

The analysis for this experiment mirrored the analysis for the previous studies[4]. The primary analysis was a 2x2 repeated measures analysis of variance (ANOVA) which ran with Perspective (Self or Other) and Consistency (Consistent or Inconsistent) as the within subject variables and Predictability condition (Predictable or Unpredictable synchrony) as the between subjects' factor.

Accuracy

To determine the effect of Predictability, Perspective, and Consistency on accuracy rates, a 3-way mixed model ANOVA was conducted. Mean accuracies per trial condition are displayed in Table 31. There was only a significant effect for Consistency effect $F(1,73)= 59.98$, $p <.001$, $\eta p^2 = .45$. Accuracy was higher for Consistent trials (M = 0.96, SD = 0.05) than Inconsistent trials (M = 0.90, SD = 0.08).

Table 31: Means (and Standard Deviations) for Accuracy in Study 8

	Predictable	Unpredictable
Own Consistent	.96 (*.05*)	.97 (*.08*)
Own Inconsistent	.91 (*.09*)	.88 (*.11*)
Other Consistent	.96 (*.08*)	.95 (*.08*)
Other Inconsistent	.90 (*.08*)	.88 (*.12*)

There was no significant effect of Perspective $F(1,73)= .98$, $p=.33$, $\eta p^2 =.01$. Nor was there a significant Perspective x Consistency interaction $F(1,73)= .08$, $p=.77$, $\eta p^2 =.00$, Consistency x Predictability interaction $F(1,73)= 2.32$, $p=.13$, $\eta p^2 =.03$, or a Perspective x Predictability interaction $F(1,73)= .00$, $p=.97$, $\eta p^2 =.00$. There was also no significant three-way interaction of Perspective x Consistency x Predictability $F(1,73)= .30$, $p=.59$, $\eta p^2 =.00$.[5]

Reaction Times

A three-way ANOVA was performed to analyse the effect of Predictability (Predictable or Unpredictable Synchrony), Perspective (Own or Other) and Consistency (Consistent or

[4] The results of the Inverse Efficiency analysis for Studies 8 and 9 are in the Appendices.
[5] As with Study 2, the results of Study 8 lost significance when it lost power as a result of exclusion criteria. See Appendices for detail.

Inconsistent) on reaction times (see Table 32). There was again a significant effect of Consistency F(1,73)= 58.83, p <.001, ηp² = .45. Reaction times were faster on Consistent trials (M = 784.08, SD = 134.97) than Inconsistent trials (M = 860.75, SD = 154.62). The difference in Consistency effect for each perspective, grouped by Predictability, are displayed in Figure 20.

Table 32: Means (and Standard Deviations) for Reaction Times in Study 8

	Predictable (*ms*)	Unpredictable (*ms*)
Own Consistent	796 (*152*)	795 (*138*)
Own Inconsistent	826 (*150*)	889 (*166*)
Other Consistent	782 (*145*)	763 (*135*)
Other Inconsistent	832 (*174*)	897 (*159*)

The Consistency x Predictability interaction was significant $F(1,73)= 13.71$, p <.001, ηp^2 = .16. In the Unpredictable Synchrony condition there was a notable Consistency effect; participants were much faster at responding correctly for Consistent trials (M =779.06, SD = 134.86) than Inconsistent trials (M =892.746, SD =154.49). There was a smaller Consistency effect for Predictable Synchrony; participants responded faster for Consistent trials (M =789.10, SD = 134.86) than Inconsistent trials (M =828.75, SD =160.80).

The Perspective x Consistency interaction failed to reach significance $F(1,73)= 3.22$, p=.08, ηp^2 = .04, as did the Perspective x Predictability interaction $F(1,73)= .34$, p=.56, ηp^2 =.01. Further, there was no significant effect of Perspective $F(1,73)= 1.20$, p= .28, ηp^2 = .02. Nor a significant Perspective x Consistency x Predictability interaction $F(1,73)= .33$, p= .57, ηp^2 = .01.

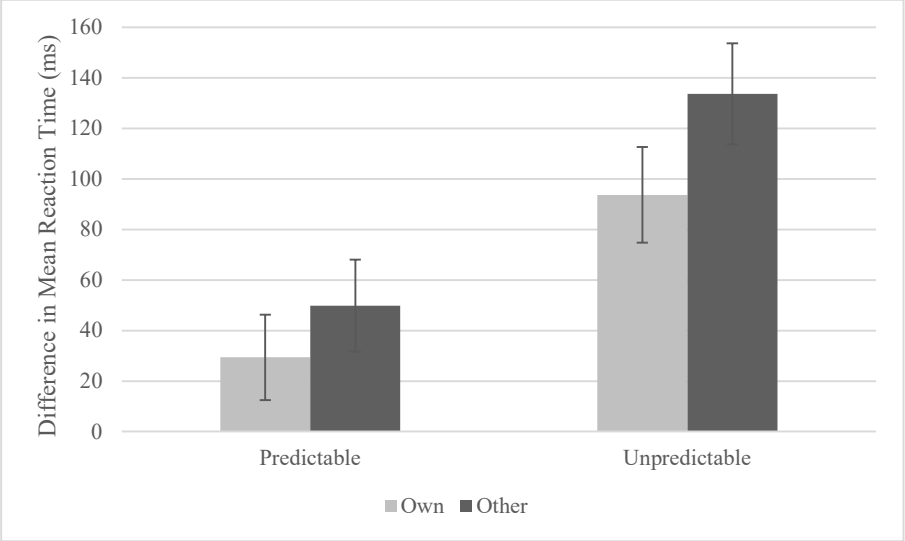


Figure 20: Reaction time Consistency Effects within each Perspective condition for the two Predictability groups in Study 8.

Additional Measures

To determine the effect of the different Predictabilities in the Coordination task on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity, an independent samples t-test was conducted (see Table 33).

Table 33: Means (and Standard Deviations) for Additional Measures in Study 8

	Predictable	Unpredictable
Similarity	42.08 (*25.57*)	47.58 (*25.28*)
Mind Attribution	4.06 (*.58*)	3.79 (*.76*)
Trust	3.38 (*.46*)	3.46 (*.50*)
Empathy	3.28 (*.50*)	3.28 (*.46*)

There was a significant difference for the Mind Attribution scale $t(73)= 4.50$, $p = .04$, $d = -0.41$. Participants who had a Predictably synchronous interaction with the confederate reported that they felt more able to attribute mental states to the confederate than those who had an Unpredictable interaction.

There was no significant difference in self-reported feelings of Similarity $t(73)= -.94$, $p = .87$, $d = 0.22$. Additionally, there was no significant difference in perceptions of Trust $t(73)= -.66$, $p = .54$, $d = 0.15$. Nor for Empathy $t(73)= -.05$, $p= .75$, $d= 0.01$.

4.2.3. Discussion

The aim of this study was to investigate how differences in perception of predictability within synchrony would influence visual perspective taking. In this study, participants were always able to synchronize with the confederate, but only one group could perceive themselves as able to predict the confederate. As predictability of the other person is a requirement of natural synchrony, it was anticipated that synchronising to an unpredictable rhythm would cause the participant to experience increased interference in the visual perspective taking task. It was theorised that synchronising with the confederate under conditions where synchrony should be difficult due to an unpredictable rhythm, would infer heightened effects of synchrony. If synchrony is perceived as effortless then synchrony is almost an expectation, whereas if synchrony is perceived as requiring focus but is still successfully engaged with, it may strengthen the internal overlap of 'self' and 'other' representation.

Notably, the results of the Predictable Synchrony condition differed to the synchrony conditions within Studies 1 to 3 of this investigation, in that there appeared to be far less interference effects overall. The level of altercentric intrusions is the minimal which we might expect for spontaneous VPT, showing participants confidence in reporting from their own perspective. However, the Predictable Synchrony condition shows far fewer egocentric intrusions than the effects of synchrony found in Studies 1 to 3 and 6 to 7. Participants were only slightly less confident in responding from the confederate's perspective than they were responding from their own. However, for Unpredictable Synchrony, the novel condition for this study, the interference effect on reaction times was somewhat stronger than other findings for synchrony in this investigation. The egocentric intrusion effects resembled the Asynchrony condition in Studies 1-2 and the time it took participants to correctly respond was much slower than anticipated. This could indicate self-other overlap, or it could be an indication of participant confusion.

Additionally, there was a significant difference in self-reported Mind Attribution consideration. Participants who had a Predictable Synchrony interaction reported that they felt more able to accurately attribute mental states to the confederate than participants who had an Unpredictable Synchrony interaction. This finding further supports the intrusion effects we see in reaction times. Predictable Synchrony gave participants confidence in their coordination and subsequent effects of synchrony. However, participants who experienced Unpredictable Synchrony clearly felt less able to judge the mental states of the confederate. As we have

established, a requirement of engaging successfully in motor synchrony is predicting the actions of your partner. Experiencing motor synchrony successfully when you can't predict the timing of your cue, or your partner, feels wrong. Furthermore, the change in methodology within this study leaves the question of whether the participants did perceive themselves as synchronised to the confederate, or to the beat. Study 8 suggests that predictability of the confederate will impact our VPT performance, however, the findings do not replicate the effects of Studies 1 to 3. Consequently, the final study in this investigation will further manipulate the perception of Predictability by separating the sensorimotor coordination cue of the audio track from the interpersonal cue of the confederate.

4.3. Study 9

4.3.1. Methodology

Overview

Investigating the effects of predictability within synchrony on VPT necessitated a change in methodology. In Study 8, participants synchronised to confederates using a beat track rather than the music track used in Studies 1 to 7. Study 8 found different effects of synchrony on VPT than was found in Studies 1 and 2. This study was devised to further explore the effects of interpersonal coordination on VPT and provide additional research using the beat track. Therefore, the focus of Study 9 was to investigate how differences of coordination can influence visual perspective taking. The expectation of this research is that predictable asynchrony (leading/following) should be perceived as a form of interpersonal coordination, such as mimicry, rather than a failure to synchronise. Whereas unpredictable/traditional asynchrony is expected to be perceived as a failure to synchronise, as with previous studies.

Participants

A power analysis determined from the previous studies in this investigation was carried out with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009). Which indicated that to detect a medium effect size, $d = 0.5$, with $1 - \beta = 0.8$ at $\alpha = 0.05$, a minimum sample size of 256 would be required, 64 in each condition for an independent samples t-test. The experiment was advertised on Prolific and data collection ran in June 2023. Participants were matched to confederates by gender and to prevent possible biases of age, the eligibility limits of 18-30 remained. 256 participants were collected but, following application of exclusion criteria, 136 were used in final analyses. Participants were randomly assigned to one of four conditions depending on the time they signed up for the study.

There were 31 participants in the ‘Synchronous’ condition (M*age* = 25.90, SD = 3.05) with 16 female participants. In the ‘Leading’ condition there were 37 participants (M*age* = 25.05, SD = 2.69) with 18 female participants. In the ‘Following’ condition there were 32 participants (M*age* = 25.13, SD =3.19) and 14 female participants. The ‘Asynchrony’ group had 36 participants (M*age* = 26.22, SD = 3.14), with 13 female participants.

Design and Materials

The investigation used a between subjects' design. There were two within subject factors. The first was Consistency; Inconsistent or Consistent, and the second was Perspective; Self and Other. The between subjects' factor was Coordination; Synchrony, Leading Asynchrony, Following Asynchrony and Unpredictable Asynchrony. The dependent variables measured were percentage of correct responses (Accuracy) and speed of correct responses (Reaction Times). Participants were randomly assigned into one of the Coordination conditions. The condition determined whether they had a predictable or unpredictable coordination task. Again, VPT was measured by a modified version of the 'dot perspective' task used in Studies 1 to 8. Following conclusion of the tasks, participants were presented with the same series of questionnaires to measure their responses to the confederate based on the experiment.

Figure 21: Screenshot of a video for the coordination task featuring the female confederate

There were two confederates to act as 'interaction partners' that participants could be paired with, one male and one female (see Figure 21). There were 22 images per confederate for the VPT task. For the Coordination task, each confederate had 5 videos created, including the example video. All participants would only see two videos. As part of their instructions the participants were shown a short 'example' video which was an extract of the 'Synchrony' video

from the confederate of the alternate gender to the one the participant was paired with. The other video participants were shown featured their paired confederate for the coordination task.

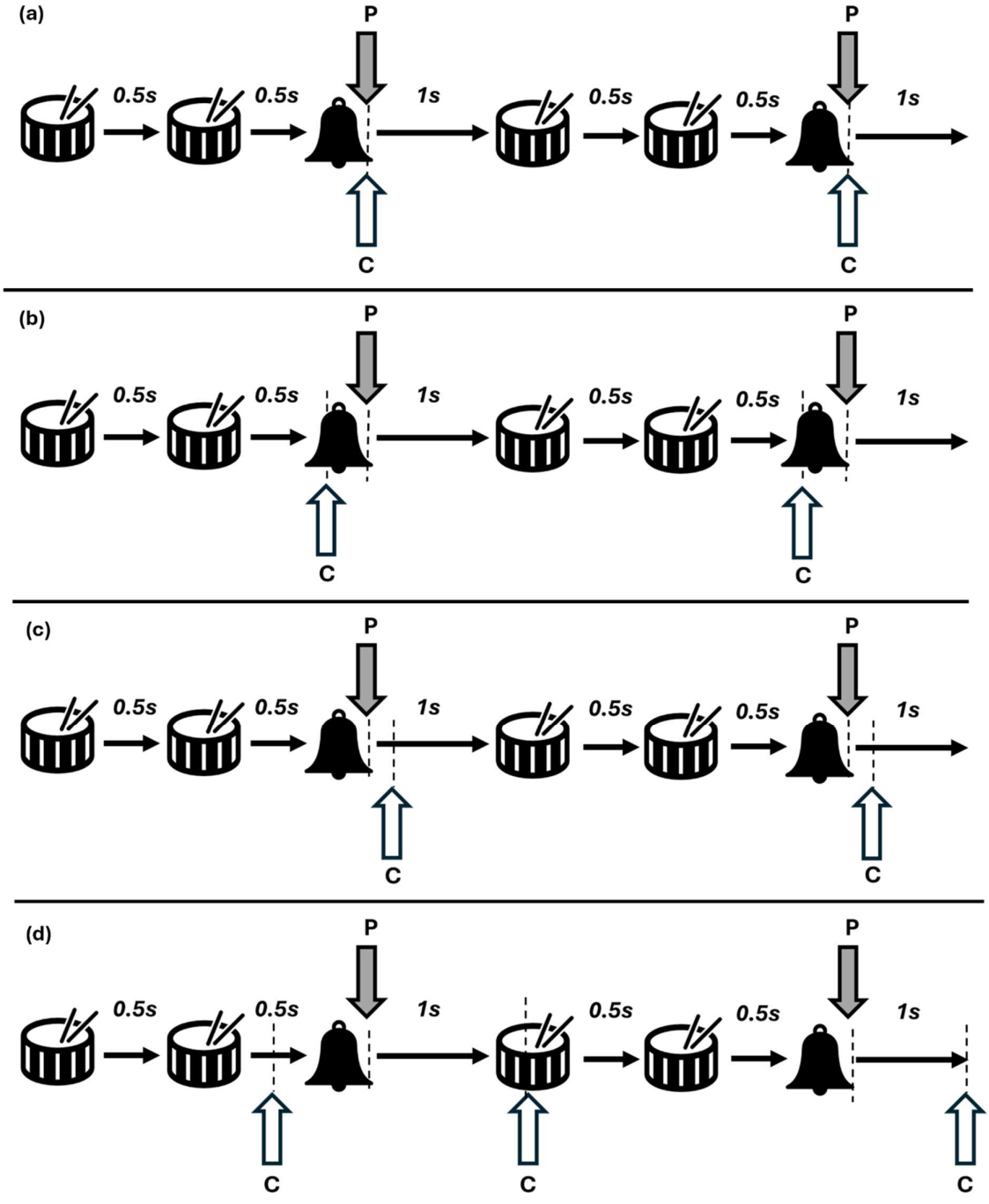


Figure 22: Visual depiction of the auditory stimuli in Study 9; Synchrony, Leading, Following and Asynchrony

The videos used a similar audio track at different bpm. The audio track that the participant heard two drumbeats followed by a 'ding' sound. The two drumbeats and 'ding' were spaced 0.5 seconds apart from each other and a full second occurred between the 'ding' and the next drumbeat (see Figure 22). The 'Synchrony' video (Figure 22-a) showed the confederate tapping at the same speed as the audio track the participant could hear. In the 'Unpredictable Asynchrony' video (Figure 22-d) the confederate was tapping their hand in a pattern that never matched the audio track that the participant was responding to. For the 'Leading Asynchrony' video (Figure 22-b) the confederate was tapping their hand to the audio track that the participant could hear but was visibly faster, so the confederate always tapped their hand just as the 'ding' sounded. The confederate was always *leading* the participant. For the 'Following Asynchrony' video (Figure 22-c) the confederate was visibly slower, always tapping their hand just as the 'ding' sound was ending. The confederate was always *following* the participant.

Procedure

As in Study 8, participants were given an audio test prior to the consent form, then asked demographic questions to ensure eligibility after consent had been granted. Participants then would see an example video of their non-gender matched confederate as part of the instructions for the Coordination task to ensure comprehension. In all conditions the participants were clearly instructed to tap their hand on the flat table in front of them when they heard the 'ding' that had been proceeded by 2 drumbeats, while watching the video on the screen.

Following the Coordination task, participants were presented with the instructions for the modified VPT task. This matched the task for Studies 1 to 8 of this investigation with the modification of the confederates which were used as perspective taking targets (avatars). Participants were then asked to complete three questionnaires (Mind Attribution Scale, Trust Scale and Empathy Quotient) and rate feelings of similarity all in relation to the confederate in immediate succession, as in Study 8. The final questions asked participants whether they did, in fact, tap their hand to the 'ding' for the whole of the Coordination task. To ensure their honesty, participants were assured that their answer would not affect whether they received compensation. Participants were also asked if, during the coordination task, they believed that the other person was listening to the same music that they were. Participants were then debriefed and encouraged to contact the researcher if they had any questions.

4.3.2. Results

Analyses

The analysis for this experiment mirrored the analysis for Study 8. The primary analysis was a 2x2x2 repeated measures analysis of variance (ANOVA) which ran with Perspective (Self or Other) and Consistency (Consistent or Inconsistent) as the within subject variables and Coordination condition (Synchronous, Leading, Following or Asynchronous) as the between subjects' factor.

Accuracy

To determine the effect of coordination, perspective, and consistency on accuracy rates, a 3-way mixed model ANOVA was conducted. Mean accuracies per trial condition are displayed in Table 34.

Table 34: Means (and Standard Deviations) for Accuracy in Study 9

	Synchrony	Leading	Following	Asynchrony
Own Consistent	.97 (*.07*)	.96 (*.07*)	.97 (*.06*)	.94 (*.08*)
Own Inconsistent	.89 (*.12*)	.89 (*.11*)	.92 (*.09*)	.87 (*.11*)
Other Consistent	.96 (*.06*)	.96 (*.06*)	.96 (*.06*)	.96 (*.06*)
Other Inconsistent	.87 (*.10*)	.87 (*.12*)	.89 (*.10*)	.84 (*.12*)

There was a significant Consistency effect $F(1,132)= 122.79$, $p <.001$, $\eta p^2 = .48$. Accuracy was higher for Consistent trials (M =.96, SD =.04) than Inconsistent trials (M =.88, SD = .01). Further there was a significant Perspective x Consistency interaction $F(1,132)= 4.99$, $p = .03$, $\eta p^2 = .08$.

However, there was not a significant effect of Perspective $F(1,132)= 3.14$, $p = .08$, $\eta p^2 = .02$. Nor were there any further two-way interactions, Perspective x Coordination $F(1,132)= .21$, $p = .89$, $\eta p^2 = .01$, Consistency x Coordination $F(1,132)= 1.01$, $p = .39$, $\eta p^2 = .02$. There was no significant three-way Perspective x Consistency x Coordination interaction $F(1,132)= .41$, $p = .74$, $\eta p^2 = .01$. This study hypothesised that the effects of Unpredictable Asynchrony would differ from the other three conditions, to further explore the results in terms of this, follow up within-condition analyses were carried out for clarification.

Synchrony

Within the Synchrony group there was a significant effect for Consistency $F(1,30)= 23.90$, $p <.001$, $\eta p^2 =.44$. Participants were more accurate in the Consistent trials (M =.96, SD = .04) than Inconsistent trials (M =.88, SD =.09). There was no significant effect of Perspective $F(1,30)= 1.63$, $p = .21$, $\eta p^2 =.05$. Nor was there a significant Perspective x Consistency interaction $F(1,30)= .33$, $p = .57$, $\eta p^2 = .01$.

Leading

There was a significant effect for Consistency $F(1,36)= 37.37$, $p <.001$, $\eta p^2 =.51$. Participants were more accurate in the Consistent trials (M =.96, SD = .04) than Inconsistent trials (M =.88, SD =.08). There was no significant effect of Perspective $F(1,36)= .47$, $p = .50$, $\eta p^2 = .01$. Nor was there a significant Perspective x Consistency interaction $F(1,36)= 1.30$, $p = .26$, $\eta p^2 = .04$.

Following

For Following, there was a significant effect for Consistency $F(1,31)= 24.33$, $p <.001$, $\eta p^2 = .44$. Participants were more accurate in the Consistent trials (M =.97, SD = .05) than Inconsistent trials (M =.91, SD =.08). There was no significant effect of Perspective $F(1,31)= 4.58$, $p = .04$, $\eta p^2 = .13$. Nor was there a significant Perspective x Consistency interaction $F(1,31)= .70$, $p= .41$, $\eta p^2 = .02$.

Asynchrony

There was a significant effect of Consistency $F(1,35)= 41.44$, $p <.001$, $\eta p^2 = .54$. Participants were more accurate in the Consistent trials (M =.95, SD = .05) than Inconsistent trials (M =.85, SD =.09). There was no significant effect of Perspective $F(1,35)= .62$, $p = .81$, $\eta p^2 = .00$. The Perspective x Consistency interaction was not significant $F(1,35)= 3.72$, $p = .06$, $\eta p^2 = .10$.

Reaction Times

A three-way ANOVA was performed to analyse the effect of Coordination (Synchrony, Leading, Following or Asynchrony), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) on reaction times (see Table 35).

Table 35: Means (and Standard Deviations) for Reaction Times in Study 9

	Synchrony (*ms*)	Leading (*ms*)	Following (*ms*)	Asynchrony (*ms*)
Own Consistent	764 (*160*)	787 (*151*)	711 (*137*)	712 (*154*)
Own Inconsistent	873 (*160*)	863 (*154*)	795 (*148*)	806 (*165*)
Other Consistent	720 (*113*)	767 (*134)*	718 (*143*)	707 (*129*)
Other Inconsistent	835 (*153*)	864 (*181*)	847 (*179*)	807 (*148*)

There was a significant Consistency effect $F(1,132)= 211.64$, $p=<.001$, $\eta p^2 =.62$. Participants were faster to respond correctly on Consistent trials (M =735.65, SD = 129.79) than Inconsistent trials (M =836.11, SD = 151.03). There was a significant interaction of Perspective x Coordination $F(1,132)= 3.49$, $p = .02$, $\eta p^2 = .07$ despite there not being a significant effect of Perspective $F(1,132)= .53$, $p = .47$, $\eta p^2 =.00$. However, there were no further significant Perspective x Consistency $F(1,132)= 2.44$, $p = .12$, $\eta p^2 = .02$., Consistency x Coordination $F(1,132)= .66$, $p = .58$, $\eta p^2 = .02$. There was also no significant three-way Perspective x Consistency x Coordination interaction $F(1,132)= .48$, $p = .70$, $\eta p^2 = .01$. The difference in consistency effect for each perspective, grouped by Coordination, are displayed in Figure 23.

Synchrony

Within the Synchrony group there was a significant effect for Consistency $F(1,30)= 53.44$, $p <.001$, $\eta p^2 = .64$. Participants were faster to respond correctly in the Consistent condition (M =741.82, SD = 125.00) than the Inconsistent condition (M =853.98, SD =145.31).

The effect for Perspective was also significant $F(1,30)= 6.21$, $p=.02$, $\eta p^2 =.17$. Participants judging from the Other perspective were slightly faster to respond correctly (M =777.44, SD =124.86) than when judging from their own perspective (M =818.35, SD =147.25). There was no significant Perspective x Consistency effect $F(1,30)= 0.54$, $p = .82$, $\eta p^2 = .00$.

Leading

There was only a significant effect for Consistency for Leading $F(1,36)= 30.45$, $p <.001$, $\eta p^2 = .46$. Participants were faster to respond correctly in the Consistent condition (M =776.57, SD = 132.72) than the Inconsistent condition (M =863.28, SD =157.87). The effect for Perspective was not significant $F(1,36)= .46$, $p = .50$, $\eta p^2 =.01$.

There was no significant Perspective x Consistency effect $F(1,36)= .84$, $p = .37$, $\eta p^2 = .02$.

Following

For Following, there was a significant effect for Consistency $F(1,31)= 98.76$, $p <.001$, $\eta p^2 = .76$. Participants were faster to respond correctly in the Consistent condition (M =714.45, SD = 127.84) than the Inconsistent condition (M =820.59, SD =153.91). The effect of Perspective was not significant $F(1,31)= 3.78$, $p=.06$, $\eta p^2 =.11$. There was no significant Perspective x Consistency interaction $F(1,31)= 2.85$, $p=.10$, $\eta p^2 =.08$.

Asynchrony

In the Asynchrony condition, there was a significant effect of Consistency $F(1, 35)= 62.10$, $p<.001$, $\eta p^2 =.64$. Participants were faster to respond correctly in the Consistent condition (M =709.78, SD =131.09) than the Inconsistent condition (M =806.59, SD =144.35). There was no significant effect of Perspective $F(1,35)= .02$, $p=.90$, $\eta p^2 =.00$. There was not a significant Perspective x Consistency interaction $F(1,35)= .07$, $p=.79$, $\eta p^2 =.00$.

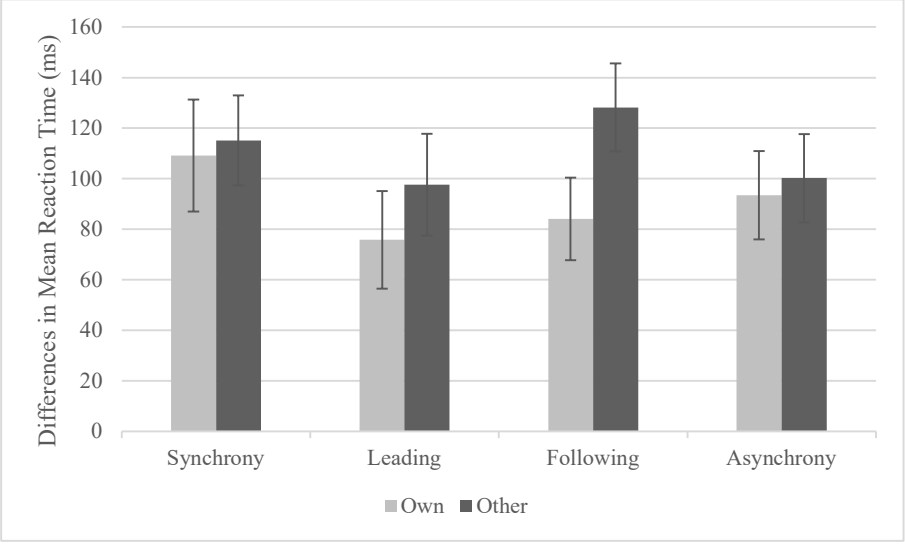


Figure 23: Reaction time Consistency Effects within each Perspective condition grouped by Coordination in Study 9.

Additional Measures

To determine the effect of Coordination on the additional self-report measures of Mind Attribution, Trust, Empathy and Similarity an independent samples t-test was conducted. The descriptive statistics are shown in Table 36.

Table 36: Means (and Standard Deviations) for Additional Measures in Study 9

	Synchrony	Leading	Following	Asynchrony
Similarity	45.68 (20.60)	51.62 (*20.86*)	44.06 (*23.74*)	47.89 (*18.96*)
Mind Attribution	4.00 (.66)	4.08 (*.71*)	4.20 (*.60*)	3.91 (*.78*)
Trust	3.28 (*.44*)	3.41 (*.39*)	3.36 (*.38*)	3.37 (*.62*)
Empathy	3.30 (*.38*)	3.45 (*.56*)	3.15 (*.64*)	3.25 (*.61*)

There was a significant difference in Empathy ratings between Leading and Following $t(67)= 2.07$, $p = .04$, $d= -0.50$. There was no significant difference between Leading and Following for Similarity $t(67)= 1.41$, $p = .16$, $d= -0.34$, Mind Attribution $t(67)= .09$, $p = .93$, $d= 0.18$ or Trust $t(67)= .09$, $p = .93$, $d= -0.13$.

There were no significant differences between Synchrony and Asynchrony for Similarity $t(101)= .98$, $p = .33$, $d=-0.19$, Mind Attribution $t(101)= 1.64$, $p = .10$, $d= -0.32$, Trust $t(101)= 1.60$, $p = .11$, $d= 0.32$ nor Empathy $t(101)= 2.02$, $p = .05$, $d= -0.40$. There were no significant differences between Synchrony and Leading for Similarity $t(102)= .09$, $p = .93$, $d= -0.02$, Mind Attribution $t(102)= -.10$, $p = .92$, $d= 0.02$, Trust $t(102)= .59$, $p = .56$, $d= -0.12$ nor Empathy $t(102)= -.39$, $p = .70$, $d= 0.08$. There were no significant differences between Synchrony and Following for Similarity $t(103)= 1.42$, $p = .16$, $d= -0.28$, Mind Attribution $t(103)= -.103$, $p = .92$, $d= 0.02$, Trust $t(103)= 1.56$, $p = .13$, $d= -0.30$ nor Empathy $t(103)= 1.30$, $p = .20$, $d= -0.25$. There were no significant differences between Leading and Asynchrony for Similarity $t(71)= .80$, $p = .43$, $d= -0.25$, Mind Attribution $t(71)= .99$, $p = .33$, $d=-0.23$, Trust $t(71)= .29$, $p = .77$, $d= 0.68$ nor Empathy $t(71)= 1.45$, $p = .08$, $d= -0.34$. There were no significant differences between Following and Asynchrony for Similarity $t(66)= -.74$, $p = .46$, $d= 0.23$, Mind Attribution $t(66)= 1.73$, $p = .09$, $d= -0.42$, Trust $t(66)= -.13$, $p = .90$, $d= 0.03$ nor Empathy $t(66)= -.65$, $p = .52$, $d= 0.16$.

A one-way ANOVA was run to compare the additional measures of the four conditions, but no significant differences were discovered.

4.3.3. Discussion

For this Study 9, the aim was to further investigate whether predictability of the confederate could explain the previously established effects of synchrony on VPT found in Chapter 2. It was intended that there would be two 'key' conditions in the investigation. The first being Synchrony compared to the three different forms of Asynchrony (Leading, Following and Unpredictable). The second being the failure to coordinate of Unpredictable Asynchrony compared to three forms of interpersonal coordination (Synchrony, Leading and Following). However, the findings of this experiment do not replicate the findings of Studies 1 to 3 on the effects that synchrony and asynchrony have on VPT. Nor are the predictable synchrony findings of Study 8 replicated. Subsequently, any interpretations of findings are limited, and no confident conclusions can be drawn.

There is some opportunity to consider patterns and possible inferences. The Leading and Following conditions were anticipated to still be processed as interpersonal coordination despite being asynchronous. The isolation and comparison of these conditions suggest some minor implications. In the Leading condition, the confederate is 'leading' the interaction, the participant is tapping to the audio cue, which manifests as following the confederates. It is probable that the participant unconsciously processes this and interprets that the confederate is understandable and predictable and so is confident in judging from their perspective in the VPT. This provides a possible explanation for the reduced interference effects in the Leading condition as well as the increased egocentric intrusions in the Following condition. In the Following condition, the participant is tapping to the audio cue but this manifests in the perception that they are leading the confederate. This discourages the perception of predictability. The participant consequently has less social information about the confederate and is reliant on their self-knowledge when perceived to have more control of sensorimotor coordination but less control of interpersonal coordination. This then translates as the interference effects on VPT. However, any theories on the patterns of results found remain speculative.

4.4. Chapter Discussion

The primary aim of Studies 8 and 9 was to investigate how perceptions of predictability within interpersonal coordination might influence Level-1 visual perspective taking (VPT). Previously, it was theorised that a possible explanation of the effects of synchrony on VPT found in Studies 1 to 3 could be due to the perceived predictability of the confederate who became the avatar. However, the findings of Studies 8 and 9 indicate that there is a larger gap of knowledge surrounding this question than anticipated. It is feasible that predictability of the confederate partner may have played a role, although it cannot be assumed to provide a sufficient explanation. The conclusions of Studies 8 and 9 are that further exploration of the social cognitive impacts of prediction within synchronous interactions should be pursued.

This Chapter contained a further research question; to explore and compare the influence of different forms of asynchronous coordination on VPT. In the previous Studies, the asynchronous condition has been manipulated to be a 'failure to synchronise'. A music track with a different bpm, and therefore a different rhythm, was overlain on the videos of confederates tapping making the participants unable to perceive their sensorimotor synchrony also as interpersonal synchrony. Studies 8 and 9 found that the confederate's 'presence' provided sufficient social context that the participants held the perception of interpersonal coordination even when following instructions of tapping to the beat. As with Study 3, even failure to synchronise has effects on VPT that differ from a control condition. In this Chapter, predictability within synchrony (Study 8) and the effects of predictable asynchrony (Study 9) were explored.

In Studies 8 and 9, all conditions replicated the original Samson et al. (2010) inconsistency effects, wherein participants were less accurate and slower to respond based on both their own and their partner's perspectives when the two perspectives were inconsistent. Further, these inconsistency effects were influenced by the prior social knowledge of the confederate, which had been provided in the coordination task, giving additional evidence for one of the aims of this investigation by demonstrating that social information about the target can influence VPT. However, the implications of the findings are not straightforward and must be considered in more depth. For instance, both Studies 8 and 9 featured a predictable synchrony condition, but neither replicated the effects of synchrony, or asynchrony, on VPT that were found in Studies 1 to 3. Nor did Study 9 replicate the effects seen in Study 8.

Therefore, any discussion of the findings can only be speculative until replication and subsequent clarity can be pursued.

Methodological differences

Studies 8 and 9 followed a similar experimental design to the previous Studies in this Investigation, with one key difference; rather than tapping to a musical track the participants were required to tap on a sound cue that was preceded by two 'warning' beats. This design change was necessary to accurately manipulate the variations of predictability stimuli from the confederate. Synchronising to auditory cues such as tones or beats is not novel for research into synchrony and coordination, however, it is the most notable deviation from the previous studies of this investigation. Studies 8 and 9 did not replicate the effects found in Studies 1 to 3, nor did Study 9 replicate the effects of Predictable synchrony found in Study 8. There is the possibility that this variation led to more cognitive effort for the participant. The beat track had a clear auditory cue which required the participant's response, whereas the music track was a continual audio which required the participants to 'keep time'. It could be argued that the music track required more concentration in the coordination task for the participant to be able to maintain the rhythm. However, music has a fluidity compared to beats. Most of us listen to music every day and unconsciously note the rhythm. Even those who would not consider themselves to be "musical" are able to tap or clap along. As such, it is likely that participants would already have a schema for following the beat of music that they could easily slip into, as opposed to tapping on a cued sound, a task that would have required additional concentration due to its unusual nature. Following two 'warning' beats is unusual and arguably unnatural to most, thus requiring additional concentration. This could contribute to the change in interference effects between the synchronous condition of Studies 1 to 3 and Studies 8 and 9. If the participants exerted greater concentration on their performance for the beat track this may have diminished the impact of the social and interpersonal element of the coordination task.

A further reflection of how this methodological change may have impacted how the participants engaged in the task, is that music allows for ignorance of errors. Small asynchronies between auditory cues and motor behaviours are not always computed. In fact, people tend to overestimate their synchrony with a rhythmic beat (Franěk, Radil, Indra, & Lánsky, 1987). Tapping to a music track can conceal any small asynchronies from a participant's conscious awareness and processing, which strengthens perceptions of synchrony.

Comparatively, attempting to tap on an exact beat, even if auditory cues are provided in advance, would likely increase awareness of small asynchronies which would then weaken perception of synchrony. This presents a possible avenue for further research, either through a replication of Studies 1 to 3 with a beat track or conceiving of a way to manipulate predictiveness of a confederate with a music track.

Influence of Predictability on VPT

Previous research has indicated that individuals can vary in their temporal prediction abilities both alone and in dyadic synchrony (Pecenka & Keller, 2011). Participants can tap along to gradual tempo changes in auditory pacing stimuli, indicating that we all have the ability to both predict and track at once. The mechanisms are not mutually exclusive, which enables the adaptive error corrections for subsequent actions. However, the ways in which we adapt our timing and future motor behaviours is dependent on the perceptual information available to us (Konvalinka, et al., 2014). Within the social context applied in Studies 1 to 9, the confederate provides perceptual information alongside the auditory stimuli. In the predictable synchrony condition of Study 8, there are no tempo changes. Participants can both anticipate the confederate's behaviour and adapt their motor behaviour with minimal effort. However, in the unpredictable synchrony condition, the participant needs to be adapting and anticipating for the length of the coordination task. The task was manipulated so participants would still be in synchrony with their confederate, but the tempo of the beat track changed throughout which likely required more effort from the participant. It was anticipated that synchronising even when it feels difficult to do so would have stronger effects on VPT and possibly greater merging of the 'self' and 'other' mental representations characterised by less difference between the degree of egocentric and altercentric intrusions. Instead, the effects were comparable to the asynchronous conditions of Studies 1 and 2. Subsequently, we theorise that unpredictable synchrony might not have been computed by the participants as synchrony, but instead as simply joint action.

Leading and Following

Individual differences may be the root of the heightened intrusions in the unpredictable synchrony condition of Study 8. Konvalinka at al., (2014) found evidence that dyads tapping to a beat might unconsciously segue into a leader-follower pattern. One person focuses on anticipating and maintaining their actions to the rhythm whilst the other focuses on adapting and synchronising to the other person. One engages in sensorimotor coordination, the other in

interpersonal and both engage in joint action. It is possible that in Study 8, the participants perceived there to be a leader-follower relationship with the confederate which then informed their VPT abilities. Additionally, being unable to predict the actions of their partner or the auditory stimuli meant that the participants reported feeling less able to judge the mental states of the confederate, contributing to the idea that they did not all perceive themselves to be synchronising.

This tentative explanation for the difference in results supports a further question that was raised in Chapter 2, namely to what degree of asynchrony is an interaction interpreted as a failure to synchronise rather than asynchronous coordination. Consequently, Study 9 was conducted in an effort to further explore how perceiving yourself to be the leader or a follower within interpersonal coordination might impact VPT. Fairhurst, Janata and Keller (2014) reported that when attempting to coordinate with partners prone to tempo drift, the best possible strategy was to take on the role of the leader. As the leader, participants assume responsibility for maintaining the tempo and adapt less to the other's irregular timing, whilst also allowing that partner to adapt to them and to become a follower. In Study 9, participants did not have this option as their 'role' in coordination was manipulated within the experiment. In the confederate Following condition, participants perceived themselves to be mimicked, they tapped to the auditory cue and the confederate appeared to be temporally adapted to them. In the confederate Leading condition, the participant was adapting to the cue of the audio and of the confederate tapping. The effects on VPT resemble the effects found as a result of synchrony in Studies 1 and 2, with reduced egocentric intrusions and increased altercentric intrusions. Due to the participants understanding of themselves to be the follower of the interaction, it appears that the mental representation of the 'other' has been brought closer to the mental representation of the 'self'. The confederate is the leader and therefore is predictable and understandable. However, the confederate Following condition results in the most egocentric intrusions but increased altercentric intrusions as well. The participant finds it difficult to take on the visual perspective of the confederate. The participant perceived themselves as being mimicked and adapted to, which has maintained the 'self' and 'other' distinction more strongly than the other conditions and made it more difficult to adjust to the other visual experience as it has been kept separate.

Unlike synchronising or failing to synchronise, leading and following interactions are only perceived to be a 'one-way' information flow. You are either receiving the information or providing it. This then affects our perceptions of the other person, our confidence in

representing their mental states as distinct from our own, and our judgements of their perspective. Leading the interaction gives confidence in your 'self' representation and the perception of confidence in the 'other' representation as you perceive yourself able to rely on your own self-knowledge. When being mimicked or followed, this confidence is absent, and the participant is reliant on their own self-knowledge. The participant is adapting to the 'other' but lack assurance in their 'self' and 'other' mental representations and how close or how distinctly apart they are.

Predictability and Interest

A further possible explanation for the difference in results between Studies 8 and 9 and Studies 1 to 7, could be the participants level of interest in the task. Ravreby, Shilat and Yeshurun (2022) had dyads play the mirror game, where they were asked to move their hands in coordination, before asking them to rate how much they liked the other person. Whilst Ravreby et al., (2022) did find the expected result that increased synchrony led to greater positive feelings towards the other person, the complexity and novelty of synchronised movements had a considerable role. This led to the belief that maintaining interest whilst synchronising might be necessary to achieve the anticipated social effects. When we engage in synchrony in the form of dancing or singing within a choir, we are not repeating the exact same behaviour for a set period, and there is more complexity in the activity which adds to the satisfaction of the task. The literature indicates that when the goal is to synchronise, the interactants will behave more predictably than they would alone (Vesper, van der Wel, Knoblich, & Sebanz, 2011). Synchrony leads to social, emotional and cognitive effects, even if it is a simple and repetitive behaviour. Despite this, we want our social interactions to be interesting which requires novelty and complexity, and therefore, we are willing to trade a degree of synchrony for an overall more enjoyable interaction. Unpredictable synchrony is more interesting than Predictable synchrony but more difficult to achieve, even if the movements remain clear cut as they did in Study 8. However, the lack of predictability comes at a cost, which in Study 8 was confidence in attributing mental states to the other person and judging from both the 'own' and 'other' visual perspectives.

Further research should consider participants levels of arousal or interest in synchronisation tasks as a possible interference in the cognitive outcomes. People have been known to voluntarily give themselves electric shocks, when given the option, rather than just watch a monotonous film fragment (Nederkoorn, Vancleef, Wilkenhöner, Claes, & Remco,

2016). Subsequently, we cannot ignore the chance that participants in the predictable coordination conditions of Studies 8 and 9 may have been a little bored. Particularly with the methodological change of the beat track rather than the music.

Chapter 5
General Discussion

5.1. General Discussion

Engaging in synchronous action helps us relate to other people as well as how we perceive ourselves and others (Launay, Tarr, & Dunbar, 2016). Existing literature has mainly focused on either the social and emotional outcomes, or the underlying neural processes that make it possible for us to engage, or fail to engage, in synchrony (Hove & Risen, 2009; Mogan, Fischer, & Bulbulia, 2017; Koban, Ramamoorthy, & Konvalinka, 2019). It is also understood that synchrony does have cognitive effects as well, including influence over our sense of 'self' (Reddish, Tong, Jong, & Whitehouse, 2020). However, research in this area has been primarily concerned with sense of agency and ownership, e.g. the rubber hand illusion (Botvinick & Cohen, 1998; Paladino, Mazzurega, Pavani, & Schubert, 2010). Synchrony is a social behaviour, and existing literature has failed to consider how synchrony might change our mental representations of the 'other' as well as 'self' during a social interaction (Jasmin, et al., 2016). Social-cognitive research into Synchrony is central to improving our understanding of how synchrony can help us relate to one another. It will improve our understanding of how engaging in synchronous action changes our perspective taking abilities as a consequence, rather than a prelude.

Humans are inherently egocentric and must adjust to take on the perspective of someone else. Nonetheless, perspective taking is influenced by our egocentric biases. Perspective taking within social interactions occurs through two main processes: embodiment and mentalising. Embodiment emphasises the link between perception and action within our cognitive functioning, that our mental states are grounded in our physical states (Lakoff & Johnson, 1999). Mentalising involves the formation of a mental representation of the 'other' that is distinct from the mental representation of 'self' and that is used to inform perspective judgements (Apperly, 2010). Interpersonal coordination within a social context theoretically affects both processes. Embodiment, through the engagement of action and perceiving the other person performing the same action, either simultaneously or with temporal delay. Mentalising, through implicitly computing that the other person has independent mental states which are aligning with our own. However, as stated above, the ways in which interpersonal coordination, specifically synchrony, influences our mental representations of 'self' and 'other' needs to be further explored. This presents us with the primary aim of this investigation. To investigate how synchrony impacts social cognition, beyond explicit social judgements.

The research into the cognitive effects of synchrony have usually required the presence of at least an experimenter, to perform the synchronous brushing or cues, if not the physical presence of coordination partner (Paladino, Mazzurega, Pavani, & Schubert, 2010). However, even in computer-based investigations, the experimental trials have been conducted in laboratory environments to ensure participant engagement and convince them of the social context (Launay, Dean, & Bailes, 2014). The first year of this investigation coincided with the end of the first wave and the duration of the second wave of Covid-19. Consequently, the restrictions required that all initial research for the investigation be conducted online. This restricted the possible experimental designs for investigating the cognitive effects of synchrony within a social context but ultimately a modification of a low-level core cognitive mechanism was selected. Specifically, how synchrony impacts a core element of Theory of Mind (ToM), namely Level-1 VPT. The ability to distinguish our own visual experience from that of another person and how that ability will be impacted by synchronising with that other person first. Study 3 conducted the investigation in person and confirmed that the online design did not cause data issues and further was preferable for the investigations time constraints.

This investigation explored how higher order social cognition can impact Level-1 VPT through the 'dot perspective task'. Building upon the work of Simpson and Todd (2017), the participant received more social information about their perspective taking target (avatar) to explore VPT abilities, rather than examining the effects of participants feelings towards the avatar on VPT performance. This necessitated providing the participant with social information and a target to mentalise. Mattan, Rotshtein and Quinn (2016) used a virtual avatar in a virtual room for a modification of the 'dot perspective task' and Bukowski and Samson (2015) were the first to utilise a confederate as the perspective taking target. This investigation advanced these methods by using a confederate in a real room for the modified 'dot perspective' VPT task.

All findings of this investigation replicated the inconsistency effects reported by Samson et al., (2010). Participants were slower and less accurate when the participant and the confederate's perspectives were inconsistent in the VPT task. This is true when judging from either the participants' or the confederates' perspectives. As such, there is confidence in the findings of this investigation and the interference within the inconsistency effects can be attributed to the prior social information of the confederate who became the perspective taking target. Table 36 summarises what prior social information was provided to participants within each Study.

Table 36: A guide to the variations of social information provided to participants about the confederate used as the visual perspective taking target in each Study.

Study	Prior social information received by the participant about the confederate
1	Synchrony and Asynchrony
2	Synchrony and Asynchrony (random assignment)
3*	Synchrony, Asynchrony and Control
4	Physical cues of similarity (w/o synchrony)
5	Pre-informed similarity (w/o synchrony)
6	Synchrony with pre-informed similarity
7	Synchrony and Asynchrony with pre-informed similarity
8	Synchrony - Predictable and Unpredictable
9	Synchrony, Predictable Asynchrony (Leading and Following) and Unpredictable Asynchrony

* Study 3 was conducted in laboratory settings, all other Studies were conducted online

In Studies 1 to 3 and 6 to 9, participants received social information about the confederate *from* the confederate, through the Coordination task. The confederate who became the static perspective taking target (avatar) in the 'dot perspective task' had first been an interaction partner that the participant had engaged in action with. This investigation shows that interference within the Inconsistency effect varied as a result of the form of coordinated action experienced by the participant. Demonstrating that prior interpersonal coordination does have influence on our visual perspective taking mechanisms.

Wheatley, Kang, Parkinson and Looser (2012) suggested that engagement in synchrony weakens our computation of another person as being a separate entity, entirely disconnected from our 'self'. This is classically characterised in the 'rubber hand illusion' where synchronous movement can create an illusion of ownership over an object (Botvinick & Cohen, 1998; Cardinali, et al., 2021; Romano, Caffa, Hernandez-Arieta, Brugger, & Maravita, 2015). Paladino, Mazzurega, Pavani, & Schubert (2010) provided evidence that this effect was not limited to objects and that the boundaries of ownership and what a person considered to be 'self' could extend to other people. However, research has also found that engagement in synchrony can lead to extension of 'other' agency over our own actions (Reddish, Tong, Jong, & Whitehouse, 2020). Studies 1, 2 and 3 investigated how synchronous action can affect our internal representations of 'self' and 'other' and finds further evidence of 'self' and 'other' being brought closer as a consequence of interpersonal synchrony.

Synchrony is arguably the strongest form of interpersonal coordination and to coordinate is to communicate. Synchrony provides interactants with implicit social information which facilitates fluid and successful interactions. However, highlighting the value of the contributions of synchrony as a form of social information to influence VPT, other forms were also examined in isolation without synchrony or coordination. Studies 4 and 5 of this investigation explored how allowing the participants to infer social information (Study 4) and directly informing the participant of social information (Study 5) about the confederate would impact VPT abilities. Although logic might suggest that being similar to someone else might make it easier for us to take on their perspective, the findings of Studies 4 and 5 support the theory that we are most successful in perspective taking when we are conscious of differences between 'self' and 'other' (Todd, Hanko, Galinsky, & Mussweiler, 2011). As anticipated by the literature, both physical cues (Study 4) and manipulated perception of similarity (Study 5) to a confederate meant that the participant approached the perspective taking task in a self-focused mindset, finding it difficult to switch to the mental representation of the other rather than projecting their own 'self' perspective. In Study 5, when participants were informed of their similarity, High Similarity participants experienced increased egocentric intrusions and reduced altercentric intrusions, indicating that they found it more difficult to adjust out of their own perspective and keep the 'other' representation distinct. Study 4 findings also suggest that whilst physical cues of similarity are unconsciously processed to support egocentric biases, characterised by increased egocentric intrusions, they lack strength as a social cue. Whereas Additional Measures findings of Study 4 instead highlight that physical cues of difference support successful perspective taking. This is characterised by significantly higher Empathy for Low Similarity condition and higher but non-significant self-reports of Similarity.

A desirable outcome of group synchrony is social bonding. Synchronising with another person makes it easier to ignore our biases and own visual experience in favour of theirs. This was shown in Studies 1 and 2 and emphasised the decrease in egocentric intrusions compared to Asynchrony (Study 1 and 2). Motor synchrony appears to make interactants better able to take on the perspectives of others through extending our 'self' representation. Study 1 also found an increase in altercentric intrusions following synchrony, implying that the 'other' representation is being brought closer to our 'self' representation. This is central to social bonding and group cohesion by making our representations of the 'other' more accessible. Synchronous movement reduces the distinction between the 'self' and 'other' representations and may even support the concept of synchronous action aiding the formation of a 'we' mental

representation, as suggested in the joint action literature (Kourtis, Woźniak, Sebanz, & Knoblich, 2019). Synchrony is a powerful social signal, affecting our perceptions of 'self' and 'other' by increasing pro-social feelings and behaviours. Synchronising with someone means that they can be internally processed as understandable, with the effects that it makes us feel more considerate of the mental states of others (Baimel, Birch, & Norenzayan, 2018). This investigation shows that through synchronous social action, implicit cognitive processes that compute the 'other' as being close to if not overlapped by the 'self' possibly act as a precursor to these social and emotional outcomes.

Whilst Study 3 was affected by significant order effects, the inclusion of a Control condition provided evidence that asynchrony, as well as synchrony, gave the participant information to form their mental representation of the 'other' and ease perspective taking. In the Control condition, the participants did not engage in any action during the coordination task and subsequently the social information was communicated by the confederate but was not received by the participant. This aimed to lead to some distinction of perception and action in the participants cognitive functioning, inhibiting possible support of embodiment from the coordination task assisting in perspective taking. In Study 4, the participants did not have a coordination task at all, their visual cues of similarity and social information were implicitly processed from the presence of the static confederate acting as the perspective taking target (avatar). In the Control condition of Study 3, the social information was provided prior to the VPT task and was manipulated to give social context but not social information. This might explain the difference in interference effects between the Control condition of Study 3 and findings of Study 4.

Chapter 4 (Studies 8 and 9) explored the contribution of action predictability within interpersonal coordination to the interference effects on VPT. The research question necessitated a difference to the experimental methods. Namely, the music track used in the coordination task was replaced with a beat track. Whilst there is precedent for the use of a non-musical auditory cue in the literature around synchrony, this difference is considered to be an explanation of why the effects of synchrony on VPT found in Chapter 2 did not replicate. Studies 8 and 9 did not replicate the effects of decreased egocentric and increased altercentric intrusions found in Studies 1, 2 and 3, nor were the effects of predictable synchrony on VPT from Study 8 replicated in Study 9. Subsequently, all possible implications of the findings are speculative.

Synchronised movement to an unchanged rhythm does not require conscious cognitive effort in humans. This extends to gradual tempo changes in auditory stimuli rhythms showing that humans can both predict and track simultaneously depending on the information available. In Studies 1 to 3 and 6 to 9, the confederate provides coordination cues in addition to the auditory stimuli cues. This causes the participants sensorimotor synchrony to the auditory cue to be processed as interpersonal coordination with the confederate. Studies 8 and 9 examine the role of prediction further by manipulating the coordination cue of the confederate. Study 8 sought to test whether synchronising with the confederate even when perceived to be effortful, due to a changing rhythm, would result in greater overlaps of 'self' and 'other' representations than had been found in Studies 1 and 2. Instead, the interference effects were more comparable to the asynchronous conditions of Studies 1 and 2. Unpredictable synchrony may not have been processed as synchrony by the participant depending on their own performance in tapping to a changing auditory cue. If the participant had internally prioritised coordinating with the changing auditory cue and not processed the confederates tapping as synchrony, instead the confederate's behaviour may have been computed as asynchronously coordinated joint action,

Predictable Synchrony had the least interference overall, possibly due to the very clear and unchanging tapping cues, which provides participants with confidence in the communicated social information that Unpredictable synchrony did not. Study 8 is the only study in this investigation to find a significant difference between the participants self-reports of their ability to attribute mental states to the confederate. This was investigated in more depth in Study 9 to investigate how predictable forms of Asynchrony would compare to different coordination forms of synchronising and failing to synchronise (Asynchrony) also used in Studies 1 to 3, 6 and 7. Once again, interference effects of previous studies did not replicate, possibly due to the change to a beat track. Explanations of the effects of predictable forms of Asynchrony are speculative.

Fairhurst, Janata and Keller (2014) reported that when attempting to coordinate with partners prone to tempo drift, the best possible strategy to maintain coordination was to take on the role of the leader. The findings of this investigation do not challenge this directly as the design of the experiment meant that participants were unable to select a Leading or Following role. However, a manipulation of the Leader and Follower roles within coordination also manipulated the participants perception of social information being communicated. Unlike synchronising or failing to synchronise, Leading and Following interactions appear to be perceived to be a 'one-way' information flow, particularly as the participants 'role' was

decided for them. As the Follower, the participant had two cues, the auditory cue and the visual cue of the confederate's action. The information flow was directed to them. As a result, the participant experienced less interference within the inconsistency effect of the VPT task. When the participant was Leading, they may have unconsciously processed themselves as directing the flow of information which increased the interference effects as they were relying on their self-knowledge.

Studies 4 and 5, which did not feature a coordination task, showed how VPT can be affected by perceptions of similarity enhancing egocentric biases, leading participants to project the 'self' rather than taking on the perspective of the 'other'. Studies 1 and 2 both found that self-reported ratings of similarity with the confederate were higher following synchrony than asynchrony. Study 3 and Studies 6 to 9 did not replicate this difference with significance. Although not significant, in Study 4 participants who were paired with the Low Similarity confederate rated them as more similar than the participants who were paired with the High Similarity confederate. Explicit, self-reported, ratings of similarity did not appear to reflect the implicit effects of similarity which influenced VPT. In Studies 6 and 7 it was found engagement in coordination benefitted assumptions of High Similarity. Synchronising and failing to synchronise both gave the participants information to form their mental representation of the 'other' rather than taking the 'easy' route of projecting the 'self'. However, perceptions of Low Similarity followed by interpersonal coordination appeared to create uncertainty. Low Similarity participants already had a difference mind-set and information to utilise in their representation of the mental states of the 'other'. Synchronising or failing to synchronise provided even more social information, seemingly making VPT a more complex process. These findings raise questions of how we utilise higher order social cognitions within social interactions, and whether some factors are given more weight than others. There is also the possibility that increased perception of familiarity with the perspective taking target through the two prior tasks may have also had influence. Within this investigation, interpersonal coordination, specifically synchronous action has been examined and found to influence VPT. However, the nature of the cues for coordination within experimental conditions are important and must feel meaningful rather than monotonous. Different forms of coordination have been explored and avenues for future research have been identified.

5.2. Limitations and Future Directions

This research paired participants to confederates of the same gender, with participants who stated that they identified as female shown a female confederate and participants who identified as male shown a male confederate. This was done to compare directly with the original Samson et al., (2010) paper and as some more recent research into perspective taking and spatial ability has found gender differences. Tarampi et al. (2016) found that women performed better than men in tests measuring spatial ability when a human figure was included. They proposed that the social information allowed women to use their perspective taking skills with support of empathy and social contexts in which these skills were originally learnt. However, Geer and Ganley (2023) ran a replication and extension of Tarampi's work and found that male participants outperformed female participants. Their findings suggested that it was spatial, not social, information which improved perspective taking performance. Consequently, the studies of this investigation did include gender matching of participant to avatar for additional analyses. That said, Studies 1 to 4 and 8 to 9 failed to find any differences between male and female participants. It should also be noted that, unfortunately, a non-binary or gender-neutral confederate could not be provided for this experiment. Participants were given the opportunity to provide an accurate gender identity (or state that they would prefer not to state their gender identity) which was recorded and noted in analyses but were matched with the female confederate for the study experimental tasks. This was an imperfect solution and reflected that psychological research still has a way to go for inclusion. However, as the gender split was included based on previous research and consideration of potential exploratory analyses, which yielded no results, this effort was deemed suitable.

Although power analyses were conducted to determine how many participants were needed for each Study, the actual number included in analyses was limited due to resources for data collection and exclusion criteria. Subsequently, throughout this investigation there is a concern of power and observed effects. Though this issue was considered and addressed within the Chapters, two post-hoc analyses were conducted to further support the conclusion of this thesis. Both the power simulation and mini-meta-analysis review of Studies 1-9 can be reviewed in the Appendices.

Studies 8 and 9 changed from the music tracks used in Studies 1 to 7, to a beat track. Whilst this was necessary for the research question, it is plausibly the cause of the differences between the effects of synchrony on VPT in Studies 1 to 2 and in Studies 8 to 9. Franěk and

colleagues (1987) found that people tend to overestimate their synchrony with a rhythmic beat. Subsequently, it is possible that the music track allowed for ignorance of minor asynchronies that the beat track did not. Further, Ravreby, Shilat and Yeshurun (2022) showed that the human desire for interesting interactions can override engagement in exact synchronous action. Music provides a rhythmic cue whilst providing enough auditory stimulation to maintain the participant's interest, whereas the beat track was an isolated cue. This explanation for the difference needs clarification. Future research should consider further ways to investigate the effects of predictability within coordination. Possibly through different stimuli that maintains the participants interest and engagement, or through investigating a different paradigm of synchrony such as speech or attention.

To go beyond this, future research could manipulate a different form of synchrony and examine the effects on VPT to see if the conclusions of this investigation apply across paradigms or if it is limited to synchronous joint action. This investigation presents an effective methodology to examine how higher order social cognitive factors, such as synchrony and similarity, can impact visual perspective taking and the design can be utilised to test a multitude of social cognitions and behaviours. Additionally, there are limited ToM tasks which can be applied to adult neurotypicals within a social context and within this investigation one core component was the focus. It would be beneficial to consider the effects of synchrony within other aspects. Therefore, a further research direction could be to use a variant of the 'Director Task' with a confederate that had been involved in a prior manipulated coordination interaction to further investigate the effect of synchrony on Theory of Mind application (Rubio-Fernández, 2016).

5.3. Thesis Summary

The research within this thesis presents a strong case that synchrony influences visual perspective taking. Motor coordination alone causes interference within VPT (Studies 1 to 3). Synchrony reduces our egocentric biases in perspective taking. Synchrony appears to bring our mental representations of 'self' and 'other' closer, an underlying cognitive effect which supports the desirous social and emotional outcomes of synchrony such as group cohesion. This is further shown in Study 1 where altercentric intrusions are increased following synchronous action. VPT abilities help us communicate and relate to one another, synchronising makes this process even easier by overlapping our mental representations to improve our understanding of the others visual experience and subsequent mental states.

This thesis has addressed the lack of published research into how synchrony can impact our cognitions beyond sense of ownership or agency. Further, it provided evidence of the ways synchrony can affect our cognitions within social interactions. Synchrony is a social behaviour, and its cognitive effects should be explored within that context. In addition, this investigation has successfully extended previous research that manipulating prior social knowledge of the perspective taking target can be a valuable method for testing how higher social cognitions impact our social interactions. Assumptions of similarity makes it more difficult to switch to the perspective of others as we tend to project our own mental states. However, engaging in motor synchrony facilitates social bonding and allows for closer mental representations of 'self' and 'other'

References

Ames, D. R. (2004). Strategies for social inference: a similarity contingency model of projection and stereotyping in attribute prevalence estimates. *Journal of Personality and Social Psychology*, 87(5), 573. https://doi.org/10.1037/0022-3514.87.5.573

Apperly, I. (2010). *Mindreaders: The Cognitive Basis of "Theory of Mind"*. London: Psychology Press. https://doi.org/10.4324/9780203833926

Arbor, A. (1964). *Election study*. Michigan: Inter-University Consortium for Political Research, University of Michigan. https://doi.org/10.3886/ICPSR07235.v4

Bailey, P. E., Slessor, G., Rendell, P., Bennetts, R., Campbell, A., & Ruffman, T. (2014). Age differences in conscious versus subconscious social perception: The influence of face age and valence on gaze following. *Psychology and Aging*, 29(3), 491-502. https://doi.org/10.1037/a0036249

Baimel, A., Birch, S. A., & Norenzayan, A. (2018). Coordinating bodies and minds: Behavioral synchrony fosters mentalizing. *Journal of Experimental Social Psychology*, 74, 281-290. https://doi.org/10.1016/j.jesp.2017.10.008.

Baker, L. J., Levin, D. T., & Saylor, M. M. (2016). The extent of default visual perspective taking in complex layouts. *Journal of Experimental Psychology: Human Perception and Performance*, 42(4), 508-518. https://doi.org/10.1037/xhp0000164

Bardy, B. G., Calabrese, C., Lellis, P. D., Bourgeaud, S., Colomer, C., Pla, S., & Bernardo, M. d. (2020). Moving in unison after perceptual interruption. *Scientific Reports*, 10, 18032. https://doi.org/10.1038/s41598-020-74914-z

Baron-Cohen, S., & Wheelwright, S. (2004). The Empathy Quotient: An Investigation of Adults with Asperger Syndrome or High Functioning Autism, and Normal Sex Differences. *Journal of Autism and Developmental Disorders*, 34, 163-175. https://doi.org/10.1023/B:JADD.0000022607.19833.00

Bernieri, F. J., & Rosenthal, R. (1991). Interpersonal coordination: Behavior matching and interactional synchrony. In R. S. Feldman, & B. Rime, *Fundamentals of nonverbal behavior* (pp. 401-432). Cambridge, UK: Cambridge University Press.

Billig, M., & Tajfel, H. (1973). Social categorization and similarity in intergroup behaviour. *European Journal of Social Psychology*, 3(1), 27-52. https://doi.org/10.1002/ejsp.2420030103

Bolt, N. K., & Loehr, J. D. (2017). The predictability of a partner's actions modulates the sense of joint agency. *Cognition*, 161, 60-65. https://doi.org/10.1016/j.cognition.2017.01.004

Botvinick, M., & Cohen, J. (1998). Rubber hand 'feels' what eyes see. *Nature*, 391, 756.

Bukowski, H., & Samson, D. (2015). Can emotions influence level-1 visual perspective taking? *Cognitive Neuroscience*, 7(1-4), 182-191. https://doi.org/10.1080/17588928.2015.1043879

Capozzi, F., & Ristic, J. (2018). How attention gates social interactions. *Annals of the New York Academy of Sciences*, 1426(1), 179-198. https://doi.org/10.1111/nyas.13854

Capozzi, F., & Ristic, J. (2020). Attention AND mentalizing? Reframing a debate on social orienting of attention. *Visual Cognition*, 28(2), 97-105. https://doi.org/10.1080/13506285.2020.1725206

Capozzi, F., Cavallo, A., Furlanetto, T., & Becchio, C. (2014). Altercentric intrusions from multiple perspectives: beyond dyads. *PloS one*, 9(12). https://doi.org/10.1371/journal.pone.0114210

Cappella, J. N. (1997). Behavioral and judged coordination in adult informal social interactions: Vocal and kinesic indicators. *Journal of Personality and Social Psychology*, 72(1), 119-131. https://doi.org/10.1037/0022-3514.72.1.119

Cardinali, L., Zanini, A., Yanofsky, R., Roy, A. C., Vignemont, F. d., Culham, J. C., & Farnè, A. (2021). The toolish hand illusion: embodiment of a tool based on similarity with the hand. *Scientific Reports*, 11. https://doi.org/10.1038/s41598-021-81706-6

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception–behavior link and social interaction. *Journal of Personality and Social Psychology*, 76(6), 893–910. https://doi.org/10.1037/0022-3514.76.6.893

Chartrand, T. L., & van Baaren, R. (2009). Human mimicry. In M. Zanna, *Advances in experimental social psychology* (Vol. 41, pp. 219-274). San Diego, CA: Elsevier Academic Press. https://doi.org/10.1016/S0065-2601(08)00405-X

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences*, 36(3), 181-204. https://doi.org/10.1017/S0140525X12000477

Cohen, M., Abargil, M., Ahissar, M., & Atzil, S. (2024). Social and nonsocial synchrony are interrelated and romantically attractive. *Communications Psychology*, 2(57). https://doi.org/10.1038/s44271-024-00109-1

Cole, G. G., Atkinson, M., Le, A. T., & Smith, D. T. (2016). Do humans spontaneously take the perspective of others? *Acta Psychologica*, 165-168. https://doi.org/10.1016/j.actpsy.2016.01.007.

Converse, B. A., Lin, S., Keysar, B., & Epley, N. (2008). In the mood to get over yourself: Mood affects theory-of-mind use. *Emotion*, 8(5), 725-730. https://doi.org/10.1037/a0013283

Costantini, M., & Haggard, P. (2007). The rubber hand illusion: sensitivity and reference frame for body ownership. *Conscious Cognition*, 16(2), 229-240. https://doi.org/10.1016/j.concog.2007.01.001

Danyluck, C., & Page-Gould, E. (2019). Social and Physiological Context can Affect the Meaning of Physiological Synchrony. *Scientific Reports*, 9, 82222. https://doi.org/10.1038/s41598-019-44667-5

Drayton, L. A., Santos, L. R., & Baskin-Sommers, A. (2018). Psychopaths fail to automatically take the perspective of others. *Proceedings of the National Academy of Sciences*, 3302-3307. https://doi.org/10.1073/pnas.1721903115

Drewing, K., Aschersleben, G., & Li, S.-C. (2006). Sensorimotor synchronization across the life span. *International Journal of Behavioral Development*, 30(3), 280-287. https://doi.org/10.1177/0165025406066764

Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze Perception Triggers Reflexive Visuospatial Orienting. *Visual Cognition*, 6(5), 509-540. 10.1080/135062899394920

Dunbar, R. (1998). The Social Brain Hypothesis. *Evolutionary Anthropology*, 6, 178-190.

Dunbar, R. I. (2009). Social Brain: Evolution. In *Encyclopedia of Neuroscience* (pp. 21-26). Amsterdam: Elsevier.

Epley, N., & Gilovich, T. (2006). The Anchoring-and-Adjustment Heuristic: Why the Adjustments Are Insufficient. *Psychological Science*, 17(4), 311–318. https://doi.org/10.1111/j.1467-9280.2006.01704.x

Epley, N., Keysar, B., Van Boven, L., & Gilovich, T. (2004). Perspective Taking as Egocentric Anchoring and Adjustment. *Journal of Personality and Social Psychology*, 87(3), 327–339. https://doi.org/10.1037/0022-3514.87.3.327

Epley, N., Morewedge, C. K., & Keysar, B. (2004). Perspective taking in children and adults: Equivalent egocentrism but differential correction. *Journal of Experimental Social Psychology*, 40(6), 760-768. https://doi.org/10.1016/j.jesp.2004.02.002

Fairhurst, M., Janata, P., & Keller, P. (2013). Being and feeling in sync with an adaptive virtual partner: Brain mechanisms underlying dynamic cooperativity. *Cerebral Cortex*, 23(11), 2592–2600. https://doi.org/10.1093/cercor/bhs243

Fairhurst, M., Janata, P., & Keller, P. (2014). Leading the follower: an fMRI investigation of dynamic cooperativity and leader–follower strategies in synchronization with an adaptive virtual partner. *Neuroimage*, 84, 688-697. https://doi.org/10.1016/j.neuroimage.2013.09.027

Falk, S., Müller, T., & Dalla Bella, S. (2015). Non-verbal sensorimotor timing deficits in children and adolescents who stutter. *Frontiers in Psychology*, 6, 847. https://doi.org/10.3389/fpsyg.2015.00847

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. 41, 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Ferguson, H. J., Brunsdon, V. E., & Bradford, E. E. (2018). Age of avatar modulates the altercentric bias in a visual perspective-taking task: ERP and behavioral evidence. *Cognitive, Affective & Behavioral Neuroscience*, 18(6), 1298-1319. https://doi.org/10.3758/s13415-018-0641-1

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, 7(2), 117-140. https://doi.org/10.1177/001872675400700202

Fizke, E., Barthel, D., Peters, T., & Rakoczy, H. (2014). Executive function plays a role in coordinating different perspectives, particularly when one's own perspective is involved. *Cognition*, 130(3), 315-334. https://doi.org/10.1016/j.cognition.2013.11.017

Flavell, J. H., Everett, B. A., Croft, K., & Flavell, E. R. (1981). Young children's knowledge about visual perception: Further evidence for the Level 1–Level 2 distinction. *Developmental Psychology*, 17(1), 99–103. https://doi.org/10.1037/0012-1649.17.1.99

Franěk, M., Radil, T., Indra, M., & Lánsky, P. (1987). Following complex rhythmical acoustical patterns by tapping. *International Journal of Psychophysiology*, 5(3), 187-192. https://doi.org/10.1016/0167-8760(87)90005-5

Frith, C. D., & Frith, U. (2006). How we predict what other people are going to do. *Brain Research*, 1079(1), 36-46. https://doi.org/10.1016/j.brainres.2005.12.126

Frith, C., & Frith, U. (2008). Implicit and explicit processes in social cognition. *Neuron*, 603, 503-510. https://doi.org/10.1016/j.neuron.2008.10.032

Galinsky, A. D., Magee, J. C., Inesi, M. E., & Gruenfeld, D. H. (2006). Power and Perspectives Not Taken. *Psychological Science*, 17(12), 1068-1074. https://doi.org/10.1111/j.1467-9280.2006.01824.x

Gawronski, B., & Quinn, K. A. (2013). Guilty by mere similarity: Assimilative effects of facial resemblance on automatic evaluation. *Journal of Experimental Social Psychology*, 49(1), 120-125. https://doi.org/10.1016/j.jesp.2012.07.016

Gazzola, V., Aziz-Zadeh, L., & Keysers, C. (2006). Empathy and the somatotopic auditory mirror system in humans. *Current Biology*, 16(18), 1824-1829. https://doi.org/10.1016/j.cub.2006.07.072

Geer, E. A., & Ganley, C. M. (2023). Sex differences in social and spatial perspective taking: A replication and extension of Tarampi et al. (2016). *Quarterly Journal of Experimental Psychology*, 76(1), 93-108. https://doi.org/10.1177/17470218221085117

Goldman, A. (2006). *Simulating minds: The philosophy, psychology, and neuroscience of mind reading*. New York: Oxford University Press. https://doi.org/10.1093/0195138929.001.0001

Hewstone, M., Rubin, M., & Willis, H. (2002). Intergroup bias. *Annual Review of Psychology*, 53, 575-604. https://doi.org/10.1146/annurev.psych.53.100901.135109

Holyoak, K. J., & Gordon, P. C. (1983). Social reference points. *Journal of Personality and Social Psychology*, 44(5), 881-887. https://doi.org/10.1037/0022-3514.44.5.881

Hove, M. J., & Risen, J. L. (2009). It's All in the Timing: Interpersonal synchrony increases affiliation. *Social Cognition*, 27, 949-961. https://doi.org/10.1521/soco.2009.27.6.949

Howard, E. M., Ropar, D., Newport, R., & Tunçgenç, B. (2021). Social context facilitates visuomotor synchrony and bonding in children and adults. *Scientific Reports*, 11, 22869. https://doi.org/10.1038/s41598-021-02372-2

Iversen, J. R., & Balasubramaniam, R. (2016). Synchronization and temporal processing. *Current Opinion in Behavioral Sciences*, 8, 175-180. https://doi.org/10.1016/j.cobeha.2016.02.027

Jasmin, K. M., McGettigan, C., Agnew, Z. K., Lavan, N., Josephs, O., Cummins, F., & Scott, S. K. (2016). Cohesion and Joint Speech: Right Hemisphere Contributions to Synchronized Vocal Production. *Journal of Neuroscience*, 36(17), 4669-4680. https://doi.org/10.1523/JNEUROSCI.4075-15.2016

Keller, P. (2008). Joint action in music performance. In F. Morganti, A. Carassa, & G. Riva, *Enacting intersubjectivity: a cognitive and social perspective to the study of interactions* (pp. 205-221). Amsterdam: IOS Press.

Keller, P. E., & Appel, M. (2010). Individual differences, auditory imagery, and the coordination of body movements and sounds in musical ensembles. *Music Perception*, 28, 27-46. https://doi.org/10.1525/mp.2010.28.1.27

Keller, P. E., Novembre, G., & Hove, M. J. (2014). Rhythm in joint action: psychological and neurophysiological mechanisms for real-time interpersonal coordination. *Philosophical Transactions of the Royal Society B*, 369, 20130394. https://doi.org/10.1098/rstb.2013.0394

Kinreich, S., Djalovski, A., Kraus, L., Louzoun, Y., & Feldman, R. (2017). Brain-to-Brain Synchrony during Naturalistic Social Interactions. *Scientific Reports*, 7, 17060. https://doi.org/10.1038/s41598-017-17339-5

Kirschner, S., & Tomasello, M. (2009). Joint drumming: Social context facilitates synchronization in preschool children. *Journal of Experimental Child Psychology*, 102(3), 299-314. https://doi.org/10.1016/j.jecp.2008.07.005

Koban, L., Ramamoorthy, A., & Konvalinka, I. (2019). Why do we fall into sync with others? Interpersonal synchronization and the brain's optimization principle. Social *Neuroscience*, 14(1), 1-9. https://doi.org/10.1080/17470919.2017.1400463

Konvalinka, I., Bauer, M., Stahlhut, C., Hansen, L. K., Roepstorff, A., & Frith, C. D. (2014). Frontal alpha oscillations distinguish leaders from followers: Multivariate decoding of mutually interacting brains. *NeuroImage*, 94, 79-88. https://doi.org/10.1016/j.neuroimage.2014.03.003

Konvalinka, I., Vuust, P., Roepstorff, A., & Frith, C. D. (2010). Follow you, Follow me: Continuous Mutual Prediction and Adaptation in Joint Tapping. *Quarterly Journal of Experimental Psychology*, 63(11), 2220-2230. https://doi.org/10.1080/17470218.2010.497843

Kourtis, D., Woźniak, M., Sebanz, N., & Knoblich, G. (2019). Evidence for we-representations during joint action planning. *Neuropsychologia*, 131, 73-89. https://doi.org/10.1016/j.neuropsychologia.2019.05.029

Kozak, M. N., Marsh, A. A., & Wegner, D. M. (2006). What do I think you're doing? Action identification and mind attribution. *Journal of Personality and Social Psychology*, 90(4), 543-555. https://doi.org/10.1037/0022-3514.90.4.543

Kronbichler, L., Stelzig-Schöler, R., Pearce, B.-G., Tschernegg, M., Said-Yürekli, S., Crone, J. S., Uscatescu, L.-C., Reich, L. A., Weber, S., Aichhorn, W., Perner, J., Kronbichler, M. (2019). Reduced spontaneous perspective taking in schizophrenia. Psychiatry Research: *Neuroimaging*, 292, 5-12. https://doi.org/10.1016/j.pscychresns.2019.08.007

Kunda, Z. (1987). Motivated inference: Self-serving generation and evaluation of causal theories. *Journal of Personality and Social Psychology*, 53(4), 636-647. https://doi.org/10.1037/0022-3514.53.4.636

Lakens, D., & Stel, M. (2011). If They Move in Sync, They Must Feel in Sync: Movement Synchrony Leads to Attributions of Rapport and Entitativity. *Social Cognition*, 29(1), 1-14. https://doi.org/10.1521/soco.2011.29.1.1

Lakoff, G. J., & Johnson, M. (1999). *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. New York: NY: Basic Books.

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, 6(5), 541-567. https://doi.org/10.1080/135062899394939

Launay, J., Dean, R., & Bailes, F. (2014). Synchronising movements with the sounds of a virtual partner enhances partner likeability. *Cognitive Processing*, 15, 491-501. https://doi.org/10.1007/s10339-014-0618-0

Launay, J., Tarr, B., & Dunbar, R. I. (2016). Synchrony as an Adaptive Mechanism for Large-Scale Human Social Bonding. *Ethology*, 122(10), 779-789. https://doi.org/10.1111/eth.12528

Lelonkiewicz, J. R., & Gambi, C. (2016). Spontaneous adaptation explains why people act faster when being imitated. *Psychonomic Bulletin & Review*, 24, 842-848. https://doi.org/10.3758/s13423-016-1141-3

Liviatan, I., Trope, Y., & Liberman, N. (2008). Interpersonal similarity as a social distance dimension: Implications for perception of others' actions. *Journal of Experimental Social Psychology*, 44(5), 1256-1269. https://doi.org/10.1016/j.jesp.2008.04.007

Louwerse, M. M., Dale, R., Bard, E. G., & Jeuniaux, P. (2012). Behavior matching in multimodal communication is synchronized. *Cognitive Science*, 36(8), 1404-1426. https://doi.org/10.1111/j.1551-6709.2012.01269.x

Lumsden, J., Miles, L. K., & Macrae, C. N. (2014). Sync or sink? Interpersonal synchrony impacts self-esteem. *Frontiers in Psychology*, 5, 1064. https://doi.org/10.3389/fpsyg.2014.01064

Ma, K., & Hommel, B. (2015). The role of agency for perceived ownership in the virtual hand illusion. *Consciousness and Cognition*, 36, 277-288. https://doi.org/10.1016/j.concog.2015.07.008

MacDorman, K. F., & Preethi Srinivas, H. P. (2013). The uncanny valley does not interfere with level 1 visual perspective taking. *Computers in Human Behavior*, 29(4), 1671-1685. https://doi.org/10.1016/j.chb.2013.01.051

Macrae, C. N., Duffy, O. K., Miles, L. K., & Lawrence, J. (2008). A case of hand waving: Action synchrony and person perception. *Cognition*, 109(1), 152-156. https://doi.org/10.1016/j.cognition.2008.07.007.

Martin, M. G. (1992). Sight and touch. In T. Crane, *The Contents of Experience* (pp. 196-215).

Mattan, B. D., Rotshtein, P., & Quinn, K. A. (2016). Empathy and visual perspective-taking performance. *Cognitive Neuroscience*, 7(1-4), 170-181. https://doi.org/10.1080/17588928.2015.1085372

Mattan, B., Quinn, K. A., Apperly, I. A., Sui, J., & Rotshtein, P. (2014). Is it always me first? Effects of self-tagging on third-person perspective-taking. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 41(4), 1100-1117. https://psycnet.apa.org/doi/10.1037/xlm0000078

Matthews, T. E., Witek, M. A., Thibodeau, J. L., Vuust, P., & Penhune, V. B. (2022). Perceived Motor Synchrony with the Beat is More Strongly Related to Groove Than Measured Synchrony. *Music Perception*, 39(5), 423-442. https://doi.org/10.1525/mp.2022.39.5.423

Mayo, O., & Gordon, I. (2020). In and out of synchrony—Behavioral and physiological dynamics of dyadic interpersonal coordination. *Psychphysiology*, 57(6), e13574. https://doi.org/10.1111/psyp.13574

Miles, L. K., Griffiths, J. L., Richardson, M. J., & Macrae, C. N. (2010). Too late to coordinate: Contextual influences on behavioral synchrony. *European Journal of Social Psychology*, 52-60. https://doi.org/10.1002/ejsp.721

Miles, L. K., Lumsden, J., Richardson, M. J., & Macrae, C. N. (2011). Do birds of a feather move together? Group membership and behavioral synchrony. *Experimental Brain Research*, 211, 495-503. https://doi.org/10.1007/s00221-011-2641-z

Miles, L. K., Nind, L. K., & Macrae, C. N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology*, 45(3), 585-589. https://doi.org/10.1016/j.jesp.2009.02.002

Miles, L. K., Nind, L. K., Henderson, Z., & Macrae, C. N. (2010). Moving memories: Behavioral synchrony and memory for self and others. *Journal of Experimental Social Psychology*, 46(2), 457-460. https://doi.org/10.1016/j.jesp.2009.12.006

Mogan, R., Fischer, R., & Bulbulia, J. A. (2017). To be in synchrony or not? A meta-analysis of synchrony's effects on behavior, perception, cognition and affect. *Journal of Experimental Social Psychology*, 72, 13-20. https://doi.org/10.1016/j.jesp.2017.03.009

Murray, S. L., Holmes, J. G., Bellavia, G., Griffin, D. W., & Dolderman, D. (2002). Kindred spirits? The benefits of egocentrism in close relationships. *Journal of Personality and Social Psychology*, 82(4), 563-581. https://doi.org/10.1037/0022-3514.82.4.563

Néda, Z., Ravasz, E., Brechet, Y., Vicsek, T., & Barabási, A.-L. (2000). The sound of many hands clapping. *Nature*, 403, 849-850. https://doi.org/10.1038/35002660

Nederkoorn, C., Vancleef, L., Wilkenhöner, A., Claes, L., & R. C. (2016). Self-inflicted pain out of boredom. *Psychiatry Research*, 30(237), 127-132. https://doi.org/10.1016/j.psychres.2016.01.063

Newman, B., & Newman, P. (1991). *Development through life: A psychosocial approach* (5 ed.). Thomson Brooks/Cole Publishing Co.

Newman-Norlund, R. D., Schie, H. T., Zuijlen, A. M., & Bekkering, H. (2007). The mirror neuron system is more active during complementary compared with imitative action. *Nature Neuroscience*, 10, 817-818. https://doi.org/10.1038/nn1911

Nielsen, M. K., Slade, L., Levy, J. P., & Holmes, A. (2015). Inclined to see it your way: Do altercentric intrusion effects in visual perspective taking reflect an intrinsically social process? *Quarterly Journal of Experimental Psychology*, 68(10), 1931–1951. https://doi.org/10.1080/17470218.2015.1023206

Novembre, G., Sammler, D., & Keller, P. E. (2016). Neural alpha oscillations index the balance between self-other integration and segregation in real-time joint action.

Neuropsychologia, 89, 414-425. https://doi.org/10.1016/j.neuropsychologia.2016.07.027

O'Brien, E., & Ellsworth, P. C. (2012). More Than Skin Deep: Visceral States Are Not Projected Onto Dissimilar Others. *Psychological Science*, 23(4), 391-396. https://doi.org/10.1177/0956797611432179

O'Grady, C., Scott-Phillips, T., Lavelle, S., & Smith, K. (2020). Perspective-taking is spontaneous but not automatic. *Quarterly Journal of Experimental Psychology*, 73(10), 1605–1628. https://doi.org/10.1177/1747021820942479

Paladino, M.-P., Mazzurega, M., Pavani, F., & Schubert, T. W. (2010). Synchronous Multisensory Stimulation Blurs Self-Other Boundaries. *Psychological Science*, 21(9), 1202–1207. https://doi.org/10.1177/0956797610379234

Patel, A. D. (2006). Musical rhythm, linguistic rhythm, and human evolution. *Music Perception*, 24(1), 99-104. https://doi.org/10.1525/mp.2006.24.1.99

Patel, A. D., Iversen, J. R., Bregman, M. R., Schulz, I., & Schulz, C. (2008). Investigating the human-specificity of synchronization to music. *Proceedings of the 10th International Conference on Music Perception and Cognition* (pp. 100-104). Sapporo; Adelaide: Hokkaido University; Casual Productions.

Paxton, A., & Dale, R. (2013). Argument disrupts interpersonal synchrony. *Quarterly Journal of Experimental Psychology*, 66(11), 2092–2102. https://doi.org/10.1080/17470218.2013.853089

Pecenka, N., & Keller, P. E. (2011). The role of temporal prediction abilities in interpersonal sensorimotor synchronization. *Experimental Brain Research*, 211, 505-515. https://doi.org/10.1007/s00221-011-2616-0

Pesimena, G., & Soranzo, A. (2023). Both the domain-general and the mentalising processes affect visual perspective taking. *Quarterly Journal of Experimental Psychology*, 76(3), 469-484. https://doi.org/10.1177/17470218221094310

Pezzulo, G. (2011). Shared Representations as Coordination Tools for Interaction. *Review of Philosophy and Psychology*, 2, 303-333. https://doi.org/10.1007/s13164-011-0060-5

Phillips-Silver, J., Aktipis, C. A., & Bryant, G. A. (2010). The Ecology of Entrainment: Foundations of Coordinated Rhythmic Movement. *Music Perception*, 28(1), 3-14. https://doi.org/10.1525/mp.2010.28.1.3

Premack, D. & Woodruff, D. (1978). Does the chimpanzee have a theory of mind. *Behavioural and Brain Sciences*, 4, 515-526. https://doi.org/10.1017/S0140525X00076512

Prinz, W. (1997). Perception and Action Planning. *European Journal of Cognitive Psychology*, 9(2), 129-154. https://doi.org/10.1080/713752551

Quesque, F., & Rossetti, Y. (2020). What do theory-of-mind tasks actually measure? Theory and practice. *Perspectives on Psychological Science*, 15(2), 384-396. https://doi.org/10.1177/1745691619896607

Qureshi, A. W., Apperly, I. A., & Samson, D. (2010). Executive function is necessary for perspective selection, not Level-1 visual perspective calculation: Evidence from a dual-task study of adults. *Cognition*, 230-236. 10.1016/j.cognition.2010.08.003

Rabinowitch, T.-C., & Knafo-Noam, A. (2015). Synchronous Rhythmic Interaction Enhances Children's Perceived Similarity and Closeness towards Each Other. *PLoS one*, 10(4). https://doi.org/10.1371/journal.pone.0120878

Ramseyer, F., & Tschacher, W. (2011). Nonverbal synchrony in psychotherapy: Coordinated body movement reflects relationship quality and outcome. *Journal of Consulting and Clinical Psychology*, 79(3), 284-295. https://doi.org/10.1037/a0023419

Ravreby, I., Shilat, Y., & Yeshurun, Y. (2022). Liking as a balance between synchronization, complexity and novelty. *Scientific Reports*, 3181. https://doi.org/10.1038/s41598-022-06610-z

Reddish, P., Bulbulia, J., & Fischer, R. (2014). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior*, 4(1), 3-19. https://doi.org/10.1080/2153599X.2013.764545

Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PloS one*, 8(8), e71182. https://doi.org/10.1371/journal.pone.0071182

Reddish, P., Tong, E. M., Jong, J., & Whitehouse, H. (2020). Interpersonal synchrony affects performers' sense of agency. *Self and Identity*, 19(4), 389-411. https://doi.org/10.1080/15298868.2019.1604427

Remple, J., Holmes, J., & Zanna, M. (1985). Trust in close relationships. *Journal of Personality & Social Psychology*, 49, 95-112. https://doi.org/10.1037/0022-3514.49.1.95

Repp, B. H. (2005). Sensorimotor synchronization: a review of the tapping literature. *Psychonomic Bulletin and Review*, 12(6), 969-992. https://doi.org/10.3758/BF03206433

Repp, B. H., & Su, Y.-H. (2013). Sensorimotor synchronization: A review of recent research (2006–2012). *Psychonomic Bulletin & Review*, 20, 403-452. https://doi.org/10.3758/s13423-012-0371-2

Richardson, M. J., & Chemero, A. (2014). Complex Dynamical Systems and Embodiment. In L. Shapiro (Ed.), *The Routledge Handbook of Embodied Cognition* (pp. 39-50). London: Routledge.

Richardson, M. J., Marsh, K. L., Isenhower, R. W., Goodman, J. R., & Schmidt, R. (2007). Rocking together: Dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science*, 26(6), 867-891. https://doi.org/10.1016/j.humov.2007.07.002

Risen, J. L., & Critcher, C. R. (2011). Visceral fit: While in a visceral state, associated states of the world seem more likely. *Journal of Personality and Social Psychology*, 100(5), 777. https://doi.org/10.1037/a0022460

Rizzolatti, G. (2005). The mirror neuron system and its function in humans. *Anatomy and Embryology*, 210, 419-421. https://doi.org/10.1007/s00429-005-0039-z

Romano, D., Caffa, E., Hernandez-Arieta, A., Brugger, P., & Maravita, A. (2015). The robot hand illusion: Inducing proprioceptive drift through visuo-motor congruency. *Neuropsychologia*, 70, 414-420. https://doi.org/10.1016/j.neuropsychologia.2014.10.033

Ross, L., Greene, D., & House, P. (1977). The “false consensus effect”: An egocentric bias in social perception and attribution processes. *Journal of Experimental Social Psychology*, 13(3), 279-301. https://doi.org/10.1016/0022-1031(77)90049-X

Rosso, M., Maes, P. J., & Leman, M. (2021). Modality-specific attractor dynamics in dyadic entrainment. *Scientific Reports*, 11, 18355. https://doi.org/10.1038/s41598-021-96054-8

Rubia, K., Taylor, A., Taylor, E., & Sergeant, J. A. (1999). Synchronization, Anticipation, and Consistency in Motor Timing of Children with Dimensionally Defined Attention Deficit Hyperactivity Behaviour. *Perceptual and Motor Skills*, 89(3), 1237-1258. https://doi.org/10.2466/pms.1999.89.3f.1237

Rubio-Fernández, P. (2016). The director task: A test of Theory-of-Mind use or selective attention? *Psychonomic Bulletin & Review,* 24, 1121-1128. https://doi.org/10.3758/s13423-016-1190-7

Sacheli, L. M., Arcangeli, E., Carioti, D., Butterfill, S., & Berlingeri, M. (2022). Taking apart what brings us together: The role of action prediction, perspective-taking, and theory of mind in joint action. *Quarterly Journal of Experimental Psychology*, 75(7), 1228-1243. https://doi.org/10.1177/17470218211050198

Samson, D., Apperly, I. A., Braithwaite, J. J., Andrews, B. J., & Bodley Scott, S. E. (2010). Seeing it their way: Evidence for rapid and involuntary computation of what other people see. *Journal of Experimental Psychology: Human Perception and Performance*, 36(5), 1255–1266. https://doi.org/10.1037/a0018729

Santiesteban, I., Catmur, C., Hopkins, S. C., Bird, G., & Heyes, C. (2014). Avatars and Arrows: Implicit Mentalizing or Domain-General Processing? *Journal of Experimental Psychology: Human Perception and Performance*, 40(3), 929–937. https://doi.org/10.1037/a0035175

Saxbe, D. E., Edelstein, R. S., Lyden, H. M., Wardecker, B. M., Chopik, W. J., & Moors, A. C. (2017). Fathers' decline in testosterone and synchrony with partner testosterone during pregnancy predicts greater postpartum relationship investment. *Hormones and Behavior*, 90, 39-47. https://doi.org/10.1016/j.yhbeh.2016.07.005

Schoenenberg, K., Raake, A., & Koeppe, J. (2014). Why are you so slow? – Misattribution of transmission delay to attributes of the conversation partner at the far-end. *International Journal of Human-Computer Studies*, 72(5), 477-487. https://doi.org/10.1016/j.ijhcs.2014.02.004

Sebanz, N., & Knoblich, G. (2021). Progress in Joint-Action Research. *Current Directions in Psychological Science*, 30(2), 138-143. https://doi.org/10.1177/0963721420984425

Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: bodies and minds moving together. *Trends in Cognitive Sciences*, 10(2), 70-76. https://doi.org/10.1016/j.tics.2005.12.009

Simpson, A. J., & Todd, A. R. (2017). Intergroup visual perspective-taking: Shared group membership impairs self-perspective inhibition but may facilitate perspective calculation. *Cognition*, 166, 371-381. https://doi.org/10.1016/j.cognition.2017.06.003.

Slessor, G., Laird, G., Phillips, L. H., Bull, R., & Filippou, D. (2010). Age-Related Differences in Gaze Following: Does the Age of the Face Matter? *The Journals of Gerontology: Series B*, 65B(5), 536-541. https://doi.org/10.1093/geronb/gbq038

Slessor, G., Phillips, L. H., Ruffman, T., Bailey, P. E., & Insch, P. (2013). Exploring own-age biases in deception detection. *Cognition and Emotion*, 28(3), 493-506. https://doi.org/10.1080/02699931.2013.839438

Stapel, J. C., Hunnius, S., Meyer, M., & Bekkering, H. (2016). Motor system contribution to action prediction: Temporal accuracy depends on motor experience. *Cognition*, 148, 71-76. https://doi.org/10.1016/j.cognition.2015.12.007

Stewart, N. A., & Lonsdale, A. J. (2016). It's better together: The psychological benefits of singing in a choir. *Psychology of Music*, 44(6), 1240-1254. https://doi.org/10.1177/0305735615624976

Surtees, A., & Apperly, I. (2012). Egocentrism and Automatic Perspective Taking in Children and Adults. *Child Development*, 83(2), 452-460. https://doi.org/10.1111/j.1467-8624.2011.01730.x

Surtees, A., Apperly, I., & Samson, D. (2016). I've got your number: Spontaneous perspective-taking in an interactive task. Cognition, 150, 43-52. https://doi.org/10.1016/j.cognition.2016.01.014

Surtees, A., Samson, D., & Apperly, I. (2016). Unintentional perspective-taking calculates whether something is seen, but not how it is seen. Cognition, 148, 97-105. https://doi.org/10.1016/j.cognition.2015.12.010

Tarampi, M. R., Heydari, N., & Hegarty, M. (2016). A Tale of Two Types of Perspective Taking: Sex Differences in Spatial Ability. *Psychological Science*, 27(11), 1507-1516. https://doi.org/10.1177/0956797616667459

Tarr, B., Launay, J., Cohen, E., & Dunbar, R. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters*, 11(10). https://doi.org/10.1098/rsbl.2015.0767

Todd, A. R., & Simpson, A. J. (2016). Anxiety impairs spontaneous perspective calculation: Evidence from a level-1 visual perspective-taking task. *Cognition*, 156, 88-94. https://doi.org/10.1016/j.cognition.2016.08.004

Todd, A. R., Hanko, K., Galinsky, A. D., & Mussweiler, T. (2011). When Focusing on Differences Leads to Similar Perspectives. *Psychological Science*, 22(1), 134-141. https://doi.org/10.1177/0956797610392929

Toma, C., Corneille, O., & Yzerbyt, V. (2012). Holding a Mirror Up to the Self: Egocentric Similarity Beliefs Underlie Social Projection in Cooperation. *Personality and Social Psychology Bulletin*, 38(10), 1259-1271. https://doi.org/10.1177/0146167212449022

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, 28(5), 675-691. https://doi.org/10.1017/S0140525X05000129

Tsakiris, M. (2008). Looking for Myself: Current Multisensory Input Alters Self-Face Recognition. *PLoS one*, 3(12). https://doi.org/10.1371/journal.pone.0004040

Tunçgenç, B., Cohen, E., & Fawcett, C. (2015). Rock With Me: The Role of Movement Synchrony in Infants' Social and Nonsocial Choices. *Child Development*, 976-984. https://doi.org/10.1111/cdev.12354

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), 1124-1131. https://doi.org/10.1126/science.185.4157.1124

Valdesolo, P., & DeSteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion*, 11(2), 262-266. https://doi.org/10.1037/a0021302

Valdesolo, P., Ouyang, J., & DeSteno, D. (2010). The rhythm of joint action: Synchrony promotes cooperative ability. *Journal of Experimental Social Psychology*, 693-695. https://doi.org/10.1016/j.jesp.2010.03.004

Valerjev, P., & Dujmović, M. (2017). Avatars and vases: the automatic processing of what other people see. *Proceedings of the 23rd Scientific Conference: Empirical Studies in Psychology*, (pp. 70-75). University of Belgrade.

Van Boven, L., & Loewenstein, G. (2003). Social Projection of Transient Drive States. *Personality and Social Psychology Bulletin*, 29(9), 1159-1168. https://doi.org/10.1177/0146167203254597

Vesper, C., van der Wel, R. P., Knoblich, G., & Sebanz, N. (2011). Making oneself predictable: reduced temporal variability facilitates joint action coordination. *Experimental Brain Research*, 211, 517-530. https://doi.org/10.1007/s00221-011-2706-z

Vesper, C., van der Wel, R. P., Knoblich, G., & Sebanz, N. (2013). Are you ready to jump? Predictive mechanisms in interpersonal coordination. *Journal of Experimental Psychology: Human Perception and Performance*, 39(1), 48-61. https://psycnet.apa.org/doi/10.1037/a0028066

Wheatley, T., Kang, O., Parkinson, C., & Looser, C. E. (2012). From Mind Perception to Mental Connection: Synchrony as a Mechanism for Social Understanding. *Social and Personality Psychology Compass*, 551-630. https://doi.org/10.1111/j.1751-9004.2012.00450.x

Wilson, A. D., & Golonka, S. (2013). Embodied cognition is not what you think it is. *Frontiers in Psychology*, 4(58). https://doi.org/10.3389/fpsyg.2013.00058

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and Cooperation. *Psychological Science*, 20(1), 1-5. https://doi.org/10.1111/j.1467-9280.2008.02253.x

Wolpert, D. M., Doya, K., & Kawato, M. (2003). A unifying computational framework for motor control and social interaction. *Philosophical Transactions of the Royal Society B*, 358(1431), 593–602. https://doi.org/10.1098/rstb.2002.1238

Yamagishi, T. (1986). The provisioning of a sanctioning system as a public good. *Journal of Personality & Social Psychology*, 51, 110-116. https://doi.org/10.1037/0022-3514.51.1.110

Yamagishi, T., & Yamagishi, M. (1994). *Trust and commitment in the United States and Japan. Motivation and Emotion*, 18, 129-166. https://doi.org/10.1007/BF02249397

Zimmermann, J. v., & Richardson, D. C. (2016). Verbal Synchrony and Action Dynamics in Large Groups. *Frontiers in Psychology*, 2034. https://doi.org/10.3389/fpsyg.2016.02034

Appendices

Appendix A: Mind Attribution Scale (Kozak, Marsh, & Wegner, 2006),

Compared to most people, I think that the person on the screen:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
has complex feelings	1	2	3	4	5
can experience pain	1	2	3	4	5
is capable of emotion	1	2	3	4	5
can experience pleasure	1	2	3	4	5
is able to intentionally carry out specific tasks	1	2	3	4	5
is capable of planned action	1	2	3	4	5
has goals	1	2	3	4	5
is highly conscious	1	2	3	4	5
has a good memory	1	2	3	4	5
can engage in a great deal of thought	1	2	3	4	5

Appendix B: Trust Scale

A compilation of 5 items from the Trust in Close Relationships scale (Remple, Holmes & Zanna, 1985). 3 items from the General Trust scale (Yamagishi & Yamagishi, 1994), 1 item taken from an earlier version (Yamagishi, 1986), and 1 item from the Trust in People Scale (Michigan election Study, 1964).

Compared to most people, I think that the person on the screen:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
tends to be selfish	1	2	3	4	5
is helpful	1	2	3	4	5
is basically good and kind	1	2	3	4	5
can be depended upon for help	1	2	3	4	5
is predictable	1	2	3	4	5
will stick to their promises	1	2	3	4	5
doesn't make up stories	1	2	3	4	5
can be trusted with personal information	1	2	3	4	5
is honest	1	2	3	4	5
is trustworthy	1	2	3	4	5

Appendix C: The Empathy Quotient (Baron-Cohen & Wheelwright, 2004)

Imagine that you met the person that you saw during the tapping task. Please indicate how much you agree or disagree with each of the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I would easily be able to work out what he wanted to talk about.	1	2	3	4	5
I would be able to tell if he was masking his true emotion.	1	2	3	4	5
I would be able to tell if I were intruding, even if he didn't tell me.	1	2	3	4	5
I would be good at predicting how he would feel.	1	2	3	4	5
I would be quick to spot if he was feeling awkward or uncomfortable.	1	2	3	4	5
I would be able to pick up quickly if he said one thing but meant another.	1	2	3	4	5
I would be able to easily tell if he was interested or bored with what I am saying.	1	2	3	4	5
I would be able to easily tell if he wanted to enter a conversation.	1	2	3	4	5
He would tell me that I am good at understanding how he is feeling.	1	2	3	4	5
I would be happy if he was cheerful and sad if he was glum.	1	2	3	4	5
It would worry me if he was worrying or panicky.	1	2	3	4	5
If I were with him, he would have a strong influence on my mood.	1	2	3	4	5
I would be inclined to get nervous when he seemed to be nervous.	1	2	3	4	5

I would try to look at his side of a disagreement before I make a decision.	1	2	3	4	5
If I were upset with him, I would try to 'put myself in his shoes.'	1	2	3	4	5
I would always try to consider his feelings before I do something.	1	2	3	4	5
I would always try to understand him better by imagining how things look from his perspective.	1	2	3	4	5
I would usually be able to appreciate his viewpoint, even if I do not agree with it.	1	2	3	4	5
I would find it difficult to see things from his point of view.	1	2	3	4	5
Before I do something I would try to consider how he would react to it.	1	2	3	4	5
I would find it easy to put myself in his shoes.	1	2	3	4	5

Appendix D: Pre-exclusion criteria results for Study 2

Accuracy

The ANOVA only revealed a significant effect of Consistency for accuracy $F(1,111)=40.85$, $p <.001$, $\eta p^2 =.27$. Participants were more accurate when both perspectives were consistent (M=.90, SD= .16) than when both perspectives were inconsistent (M=.83, SD= .17).

Table i: Means and Standard Deviations for Accuracy in Study 2

	Synchrony	Asynchrony
Own Consistent	.91 (*.20*)	.92 (*.17*)
Own Inconsistent	.83 (*.20*)	.84 (*.19*)
Other Consistent	.88 (*.18*)	.90 (*.21*)
Other Inconsistent	.81 (*.20*)	.84 (*.21*)

The main effect of Perspective was not significant $F(1,108)= 1.06$, $p= .31$, $\eta p^2 = .01$ and there were no interactions. There was not a significant Perspective x Consistency interaction $F(1,111)= .35$, $p= .56$, $\eta p^2 = .00$. Subsequently there was not a significant interaction effect of perspective x coordination $F(1,111)= .08$, $p= .78$, $\eta p^2 =. 00$. There was also no significant interaction effect of consistency x coordination $F(1,111)= 1.06$, $p=.31$, $\eta p^2 =.01$.

Reaction Times

There was a significant Consistency effect for reaction times $F(1,108)= 130.90$, $p <.001$, $\eta p^2 = .55$, with both groups having slower overall reaction times when both perspectives were inconsistent (M= 830.99, SD= 163.66) than when both perspectives were consistent (M=745.37, SD= 149.26).

Table ii: Means and Standard Deviations for Reaction Times in Study 2

	Synchrony	Asynchrony
Own Consistent	731 (*156*)	764 (*189*)
Own Inconsistent	809 (*168*)	815 (*184*)
Other Consistent	741 (*138*)	746 (*161*)
Other Inconsistent	824 (*158)*	877 (*205*)

The main effect of Perspective was not significant $F(1,108)= 3.08$, $p=.082$, $\eta p^2 =.03$. But there was a significant Perspective x Consistency interaction effect $F(1,108)= 6.21$, $p=.014$, $\eta p^2 =.54$. Paired t-tests showed a significant Consistency effect when participants judged from their own perspective $t(112)=5.19$, $p <.001$, d=0.53, with a 64*ms* advantage in the consistent condition and a numerically larger consistency effect when participants were judging from the confederates perspective $t(109)=-9.31$, $p<.001$, d=1.03.

Furthermore, there was a significant Perspective x Consistency x Coordination interaction effect, $F(1,108)= 4.86$, $p=.030$, $\eta p^2 =.04$. There was a significant Perspective x Consistency interaction effect following an Asynchronous interaction $F(1,55)= 13.27$, $p=<.001$, $\eta p^2 =.20$. However the Perspective x Consistency interaction effect following a synchronous interaction was not significant $F(1,55)= .04$, $p=.851$, $\eta p^2 =.00$.

Paired t-tests for each Coordination condition investigated this interaction. Following an Asynchronous interaction there was a significant consistency effect when participants judged from their own perspective $t(56)=-3.62$, $p <.001$ d=0.5 with a 48*ms* advantage in the consistent condition. There was a numerically larger consistency effect when participants were judging from the confederates perspective $t(54)=-8.76$, $p<.001$ d= 1.46 with a 131*ms* advantage in the consistent condition.

Whereas, following a Synchronous interaction there was a significant consistency effect when participants judged from their own perspective $t(55)=-4.38$, $p <.001$ d=0.60 with an 80*ms* advantage in the consistent condition. There was a consistency effect when participants were judging from the confederates perspective of a similar size $t(54)=-4.88$, $p<.001$ d= 0.71. with an 82*ms* advantage to the consistent condition.

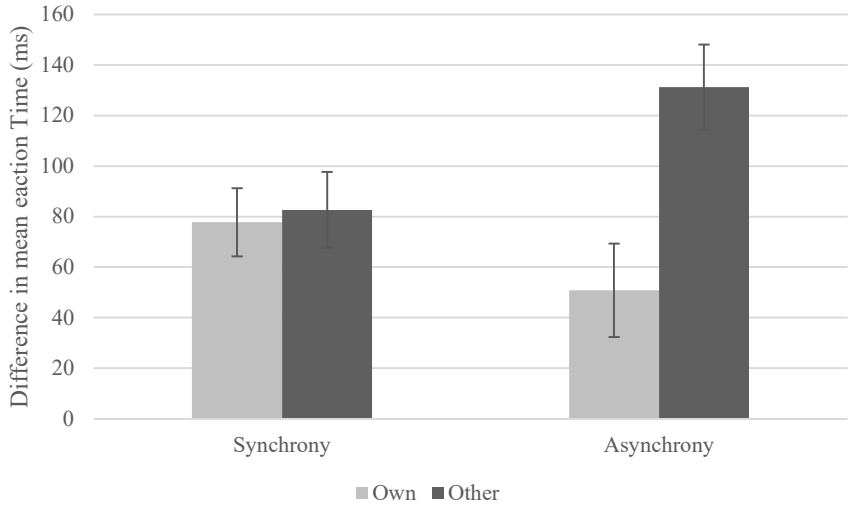


Figure i: Reaction time Consistency effects within each Perspective condition for the two Coordination.

Inverse Efficiency Score

Table iii: Means and Standard Deviations for Inverse Efficiency Scores in Study 2

	Synchrony	Asynchrony
Own Consistent	1039.87 (*1834.33*)	908.82 (*644.06*)
Own Inconsistent	1029.54 (*435.94*)	987.80 (*377.71*)
Other Consistent	886.19 (*423.99*)	797.46 (*203.47*)
Other Inconsistent	1033.29 (*293.01*)	1099.74 (*684.62*)

There was not a significant effect of Consistency $F(1,105)= 3.66$, $p= .06$, $\eta p^2 =.03$. Participants were faster to reach the correct response when their perspective and the confederate perspective were consistent (M=908.08, SD=712.44) than when they were inconsistent (M=1037.59, SD= 379.75).

There was no effect of Perspective $F(1,105)= .24$, $p=.629$, $\eta p^2 =.00$. There was no significant Perspective x Consistency interaction $F(1,105)= .82$, $p=.369$, $\eta p^2 =.02$. Paired t tests revealed that there was a significant consistency effect for the other perspective t(107)=-4.48, $p <.001$ $d= 0.59$. However, the consistency effect for the participant judging from their own perspective

was not significant $t(107)=-.28$, $p=.391$ $d= 0.02$. Furthermore, there was no significant Perspective x Consistency x Coordination interaction $F(1,105)= .06$, $p=.81$, $\eta p^2 =.00$.

Additional Measures

Once again, Participants who had a synchronous interaction with their confederate, reported higher ratings of similarity between themselves and the confederate (M = 41.21, SD = 21.87) than participants who had an asynchronous interaction (M=32.14, SD=23.99); $t(111)= -2.10$, $p= .038$.

Table iv: Means and Standard Deviations for Additional Measures in Study 2

	Synchrony	Asynchrony
Similarity	41.21 (*21.87*)	32.14 (*23.99*)
Mind Attribution	3.93 (*.73*)	3.98 (*.60*)
Trust	3.43 (*.40*)	3.31 (*.43*)
Empathy	3.36 (*.45*)	3.19 (*.53*)

There was no significant difference between the results of the Empathy Quotient $t(111) = -1.92$, $p = .06$. There was no significant difference between Synchronous and Asynchronous groups for perceived trust of the confederate $t(111)= 1.49$, $p = .14$. There was also no significant difference from the scores given for the Mind Attribution scale $t(111)= -.40$, $p= .69$.

Appendix E: Perceived (informed) Similarity Questionnaire

Questions and response options used in Studies 5, 6 and 7 within Chapter 3.

1. What is your relationship status?
    a. Single, In a relationship, Married, Widowed, Divorced, Separated, In civil partnership/civil union or similar, Rather Not Say
2. Do you identify yourself as part of the LGBTQ+ community?
    a. Yes, No, Prefer not to say
3. Do you have any children?
    a. Yes, No, Prefer not to say
4. How many siblings do you have?
    a. 0,1, 2, 3, 4, 5, 6, 7, 8, 9, 10+, Prefer not to say
5. Please indicate the number of people living in your household (excluding yourself) that you consider to be members of your family
    a. 0 ,1 ,2 ,3 ,4 ,5 ,6,7,8,9,10, Prefer not to say

6. Do you currently own any of the following as a pet?
    a. Dog, Cat, Fish, Bird, Rabbit, Reptile, Other small mammal (e.g. hamster), Other, Do not have a pet, Prefer not to say
7. How do you participate in sport?
    a. I actively take part in team sports only, I actively take part in non-team sports only (e.g. going to the gym), I actively take part in both team and non-team sports, I don’t actively take part in any sport, Prefer not to say
8. Do you play a musical instument, if so for how many years?
    a. No. I don't play a musical instrument, Yes. For 0-1 years., Yes. For 1-2 years., Yes. For 2-3 years. ,Yes. For 3-4 years. ,Yes. For 5+ years., Prefer not to say
9. Do you meditate?
    a. Yes, No, Rarely, Prefer not to say

10. Do you drink alcohol?
    a. Yes. Regularly, Yes. Sometimes, Yes. Rarely, No, Prefer not to say
11. What is your current smoking status?
    a. I am a current smoker (smoke at least 5 cigarettes a day and have smoked this amount for at least one year), I am a recent smoker (smoke at least 5 cigarettes

a day and have smoked this amount for less than one year), I am a former smoker (used to smoke at least 5 cigarettes a day and smoked this amount for at least one year), I have never smoked (smoked fewer than 100 cigarettes in my lifetime), Prefer not to say

12. Would you describe yourself as having a long-term health condition or a disability?
    a. Yes, No, Prefer not to say
13. Do you have – or have you had – a diagnosed, on-going mental health/illness/condition?
    a. Yes, No, Prefer not to say
14. Have you been diagnosed with Dyslexia, Dyspraxia or ADHD, or aware of having any related literacy difficulties?
    a. Yes, No, Prefer not to say
15. Do you have normal or corrected-to-normal vision?
    a. Yes, No, Prefer not to say

16. Do you have any dietary restrictions?
    a. Vegetarian, Vegan, Gluten-free, Sugar-free, Dairy/lactose-free, Milk allergy, Eggs allergy, Nut allergy, Soy allergy, Wheat or grain allergy Fish allergy, Fish allergy, Shellfish allergy, Other food allergies, Other dietary restriction, None, Rather not say,
17. Have you received a coronavirus (COVID-19) vaccination?
    a. Yes, No, Prefer not to say
18. Do you believe in climate change?
    a. Yes, No, Don't know, Prefer not to say
19. When it comes to others having the right to terminate their pregnancy, are you Pro Life or Pro Choice?
    a. Pro-life, Pro-choice, Don't know, Prefer not to say
20. Do you consider yourself to be religious?
    a. Yes, No, Don't know, Prefer not to say

21. Do you have a drivers licence?
    a. Yes, No, Learner's / driver's permit or provisional license, License not currently valid, Prefer not to say
22. Which of these is the highest level of education you have completed?

    a. No formal qualifications, Secondary education (e.g. GED/GCSE), High school diploma/A-levels, Technical/community college, Undergraduate degree (BA/BSc/other), Graduate degree (MA/MSc/MPhil/other), Doctorate degree (PhD/other), Don't know, Prefer not to say

23. Are you currently a student?
    a. Yes, No, Prefer not to say
24. Are you considering one of the following further study options?
    a. Undergraduate Degree, Master's Degree, Doctoral Degree, I am not considering further study, I am considering other study avenues, Prefer not to say

Appendix F: Inverse Efficiency results for Chapter 3

Study 4

A three-way ANOVA was performed to analyse the effect of Similarity (High or Low), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) in a trade-off analysis between reaction times and accuracy. Descriptives per trial condition are shown in Table v.

Table v: Means and Standard Deviations for Inverse Efficiency in Study 4

	High Similarity	Low Similarity
Own Consistent	825.82 (*187.70*)	757.18 (*173.72*)
Own Inconsistent	1033.56 (*227.83*)	898.01 (*191.74*)
Other Consistent	760.97 (*198.46*)	750.85 (*161.19*)
Other Inconsistent	1023.53 (*234.93*)	921.88 (*232.30*)

There was a significant consistency effect $F(1,86)= 221.79$, $p<.001$, $\eta p^2 =.72$. Participants were much faster to make the correct response when their perspective and the confederates perspective were consistent (M=773.70, SD=166.12) compared to inconsistent (M=969.25, SD=199.85). Further, there was a significant Consistency x Similarity interaction $F(1,86)= 9.10$, $p= .003$, $\eta p^2 = .10$.

However, there was not a significant Perspective x Consistency interaction $F(1,86)= 284$, $p= .09$, $\eta p^2 = .03$. There was not a significant Perspective effect $F(1,86)= 1.11$, $p= .30$, $\eta p^2 = .01$. Nor was there a significant Perspective x Similarity interaction effect $F(1,86)= 2.88$, $p= .09$, $\eta p^2 =.03$. Further there was not a significant Perspective x Consistency x Similarity interaction $F(1,86)= .24$, $p= .63$, $\eta p^2 = .00$.

Study 5

A three-way ANOVA was performed to analyse the effect of Similarity (High or Low), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) in a trade-off analysis. The inverse efficiency score was determined by dividing reaction times by proportion of correct responses for each participant in each trial type. Descriptive statistics per trial condition are shown in Table vi.

Table vi: Means and Standard deviations table of inverse efficiency in Study 5

	High Similarity	Low Similarity
Own Consistent	876.00 (*215.19*)	831.59 (*197.65*)
Own Inconsistent	1059.55 (*324.43*)	995.26 (*249.72*)
Other Consistent	854.18 (*175.13*)	834.34 (*211.90*)
Other Inconsistent	1082.52 (223.*89*)	1051.38 (*260.83*)

There was a significant consistency effect $F(1,96)= 162.37$, $p<.001$, $\eta p^2 =.63$. Participants were much faster to make the correct response when their perspective and the confederates' perspective were consistent (M=1047.59, SD=1164.52) compared to inconsistent (M=1306.92, SD=879.53).

The Perspective x Consistency interaction failed to reach significance $F(1,96)= 3.38$, $p= .07$, $\eta p^2 = .03$. There was no significant effect of Perspective $F(1,96)= 1.02$, $p= .32$, $\eta p^2 = .01$. Neither of the other two-way interactions was significant (largest $F(1,96)=94$, $p=.33$, $\eta p^2 = .01$), nor was the three-way interaction ($F(1,96)= .03$, $p= .87$, $\eta p^2 =.00$.)

Study 6

Table vii: Means and Standard Deviations for inverse efficiency in Study 6

	High Similarity	Low Similarity
Own Consistent	868.19 (*250.74*)	834.73 (*187.83*)
Own Inconsistent	945.59 (*245.21*)	967.18 (*211.18*)
Other Consistent	864.46 (*200.37*)	798.94 (*116.91*)
Other Inconsistent	1097.16 (*227.08*)	1030.46 (*254.54*)

There was a significant effect of Consistency $F(1,35)= 71.14$, $p<.001$, $\eta p^2 =.67$. Participants were much faster to make the correct response when their perspective and the confederate's perspective were consistent (M=841.58, SD=176.30) compared to inconsistent (M=1010.10, SD=201.22).

The Perspective x Consistency interaction was also significant $F(1,35)= 8.20$, $p=.01$, $\eta p^2 =.19$. Paired t-tests reveal a significant Consistency effect when judging from their own perspective $t(36)=-4.09$, $p<.001$, $d=0.69$ and a numerically larger consistency effect when judging from the other perspective $t(36)=-7.13$, $p<.001$, $d=1.56$.

There was no significant effect of Perspective $F(1,35)= 2.97$, $p=.09$, $\eta p^2 =.08$. Additionally, there was no significant Consistency x Similarity interaction $F(1,35)= .45$, $p=.25$, $\eta p^2 =.04$. There was no significant Perspective x Similarity interaction $F(1,35)= 1.40$, $p=.51$, $\eta p^2 =.01$. Nor was there a significant Perspective x Consistency x Similarity interaction $F(1,35)= .40$, $p=.53$, $\eta p^2 =.01$.

Study 7

A four-way ANOVA was performed to analyse the effect of Coordination (Synchrony or Asynchrony), Similarity (High or Low), Perspective (Own or Other) and Consistency (Consistent or Inconsistent) in a trade-off analysis between reaction times and accuracy. Descriptive statistics per trial condition are shown in Table viii.

Table viii: Means (and Standard Deviations) for Inverse Efficiency in Study 7

Coordination		High Similarity	Low Similarity
Synchrony	Own Consistent	782.05 (*206.86*)	779.38 (*186.18*)
	Own Inconsistent	936.37 (*275.10*)	906.39 (*212.55*)
	Other Consistent	746.08 (*187.07*)	751.63 (*171.91*)
	Other Inconsistent	931.76 (*234.31*)	992.49 (*248.62*)
Asynchrony	Own Consistent	762.36 (*195.37*)	780.41 (*188.74*)
	Own Inconsistent	892.97 (*189.41*)	932.25 (*193.62*)
	Other Consistent	775.18 (*211.38*)	802.03 (*177.27*)
	Other Inconsistent	921.62 (*249.37*)	995.15 (*231.60*)

There was significant consistency effect $F(1,193)= 491.19$, $p <.001$, $\eta p^2 = .72$. Participants were faster to respond accurately on consistent trials (M=774.64, SD=178.56) than inconsistent trials (M=938.63, SD=205.58).

There was a significant effect of Perspective $F(1,193)= 3.97$, $p=.05$, $\eta p^2 =.02$. Participants were faster to respond accurately when judging from their own perspective (M=846.52, SD=194.79) than judging from the confederates (M=866.75, SD=202.38).

There was a significant Perspective x Consistency interaction $F(1,193)= 7.85$, $p=.01$, $\eta p^2 =.04$. Paired t-tests show a significant Consistency effect when judging from their own perspective $t(196)=-13.13$, $p<.001$, $d= 1.01$ and a numerically larger consistency effect when judging from the other perspective $t(196)=-16.29$, $p <.001$, $d= 1.41$.

The interaction of Perspective x Consistency x Similarity was not significant $F(1,193)= 3.67$, $p=.06$, $\eta p^2 =.02$. The Consistency x Similarity interaction was not significant $F(1,193)= 3.70$, $p = .06$, $\eta p^2 = .02$.There was not a significant interaction of Perspective x Coordination $F(1,193)= 1.24$, $p=.27$, $\eta p^2 =.01$. Nor a significant interaction of Consistency x Coordination

$F(1,193)= 1.32$, $p=.25$, $\eta p^2 =.01$. There was also no significant interaction of Perspective x Consistency x Coordination $F(1,193)= 1.14$, $p=.29$, $\eta p^2 =.01$.

Appendix G: Inverse Efficiency results for Chapter 4

Study 8

To determine the speed-accuracy trade off following effects of Coordination and from trial condition, the inverse efficiency scores were run through a 3-way ANOVA. Descriptive statistics per trial condition are displayed in Table viii.

Table viii: Means and Standard Deviations for Inverse Efficiency Scores in Study 8

	Synchrony	Leading	Following	Asynchrony
Own Consistent	797.78 (*211.74*)	829.26 (*203.84*)	735.51 (*158.82*)	761.98 (*173.92*)
Own Inconsistent	1009.69 (*291.57*)	980.51 (*224.77*)	877.00 (*209.72*)	946.87 (*255.43*)
Other Consistent	753.38 (*137.61*)	801.10 (*157.76*)	753.00 (*192.63*)	741.42 (*158.52*)
Other Inconsistent	982.99 (*242.30*)	1020.08 (*288.05*)	962.77 (*246.78*)	985.78 (*247.54*)

There was a significant Consistency effect $F(1,132)= 212.79$, $p<.001$, $\eta p^2 =.62$. Participants were faster to reach the correct answer on consistent trials (M=771.680, SD=156.77) than inconsistent trials (M=970.71, SD=228.70).

There was also a significant perspective and consistency interaction $F(1,132)= 6.65$, $p=.01$, $\eta p^2 =.05$. However, there was not a significant effect of perspective $F(1,132)= .38$, $p=.54$, $\eta p^2 =.00$.

Study 9

To see the effects of Prediction, Perspective and Coordination on speed and accuracy trade-offs, a 3-way ANOVA was conducted. Descriptive statistics for each trial condition are displayed in Table ix.

Table ix: Means and Standard Deviations for Inverse Efficiency in Study 9

	Predictable	Unpredictable
Own Consistent	830.62 (*171.91*)	825.98 (*155.70*)
Own Inconsistent	917.96 (*218.06*)	1021.23 (*234.73*)
Other Consistent	826.73 (*184.17*)	804.38 (*147.60*)
Other Inconsistent	937.67 (*252.43*)	1038.56 (*274.14*)

There was a significant Consistency effect $F(1,73)= 100.61$, $p<.001$, $\eta p^2 =.58$. Participants were faster to reach the correct answer on consistent trials (M= 821.928, SD= 154.37) than inconsistent trials (M= 978.86, SD=229.09).

There was also a significant Consistency x Coordination effect $F(1,73)= 13.64$, $p<.001$, $\eta p^2 =.16$. In the Predictable Synchrony condition there was a notable Consistency effect; the trade-off between speed and accuracy was less for consistent trials (M=828.68, SD= 154.25) than inconsistent trials (M=927.82, SD=228.91). In the Unpredictable Synchrony condition found more of a Consistency effect with consistent trials being faster (M=815.18, SD= 154.25) than inconsistent trials (M=1029.90, SD=228.91).

There was not a significant Perspective effect $F(1,73)= .05$, $p=.82$, $\eta p^2 =.00$. Nor was there a significant Perspective x Consistency interaction $F(1,73)= 1.68$, $p=.20$, $\eta p^2 =.02$.

Appendix H: Pre-exclusion criteria results for Study 8

Accuracy:

There was a significant Consistency effect F(1,101)= 33.60, p=<.001, ηp² =.25. Accuracy was higher for consistent trials (M= 0.89, SD= 0.15) than inconsistent trials (M= 0.82, SD= 0.16).

Table x: Means and Standard Deviations for Accuracy in Study 8

	Predictable	Unpredictable
Own Consistent	.87 (*.22*)	.90 (*.18*)
Own Inconsistent	.84 (*.18*)	.82 (*.19*)
Other Consistent	.88 (*.17*)	.90 (*.15*)
Other Inconsistent	.82 (.20)	.80 (*.18*)

However, there was no significant Perspective effect $F(1,101)= .082$, $p= .78$, $\eta p^2 = .00$ and also no significant Perspective x Consistency effect $F(1,101)= 1.17$, $p= .28$, $\eta p^2 = .01$. The Consistency x Coordination interaction was not significant $F(1,101)= 3.40$, $p= .07$, $\eta p^2 = .03$. Nor was there a Perspective x Consistency x Coordination $F(1,101)= .22$, $p= .64$, $\eta p^2 = .00$.

Reaction Times:

There was a significant Consistency effect $F(1,99)= 55.59$, $p<.001$, $\eta p^2 = .36$. Reaction times were faster on consistent trials (M=792.19, SD=152.67) than inconsistent trials (M=881.26, SD=121.72).

Table xi: Means and Standard Deviations for Reaction Times in Study 8

	Predictable	Unpredictable
Own Consistent	796 (*199*)	805.68 (*155.02*)
Own Inconsistent	846.90 (*157.66*)	908.08 (*182.78*)
Other Consistent	806.64 (*161.78*)	760.77 (*148.13*)
Other Inconsistent	873.07 (*232.32*)	896.97 (*176.28*)

The Consistency x Coordination interaction was significant $F(1,101)= 6.41$, $p= .01$, $\eta p^2 = .06$. In the Unpredictable Synchrony condition there was a large consistency effect;

participants were much faster at responding correctly for Consistent trials (M=783.22, SD= 220.11) than Inconsistent trials (M=902.53, SD=247.56). There was a smaller consistency effect for Predictable synchrony; participants responded faster for consistent trials (M=801.16, SD= 211.65) than inconsistent trials (M=859.99, SD=238.04).

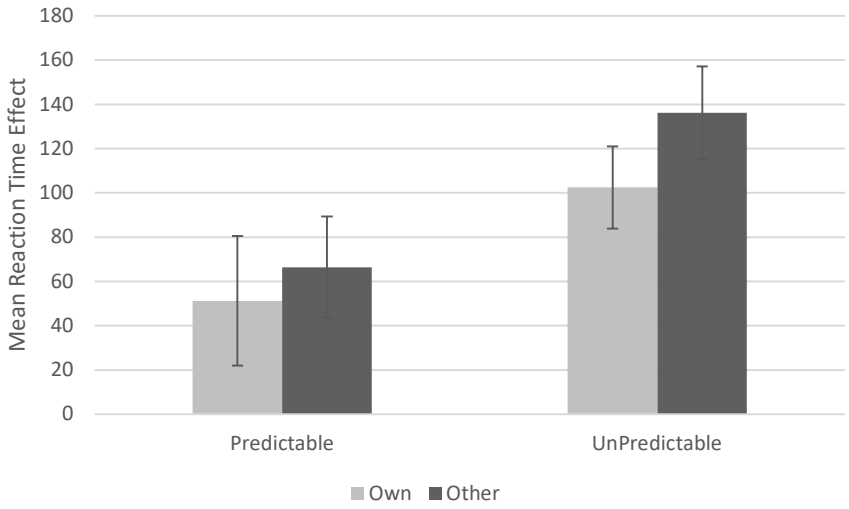


Figure ii: Reaction time Consistency effects within each Perspective condition for the two Coordination.

The Perspective x Coordination interaction was also significant $F(1,101)= 6.11$, $p=.02$, $\eta p^2 =.06$. For Predictable Synchrony this is as expected, participants responded correctly faster when judging from their own perspective (M= 821.29, SD=208.60), compared to the confederates (M= 839.86, SD= 229.46). However, for Unpredictable Synchrony we see the reverse. Participants appear to be faster to respond correctly when judging from the confederate's perspective (M= 828.87, SD=238.64) rather than when judging from their own (M= 856.88, SD= 216.95).

There was not a significant Perspective x Consistency interaction $F(1,101)= 1.11$, $p= .30$, $\eta p^2 = .011$. There was not a significant Perspective effect $F(1,101)= .25$, $p= .62$, $\eta p^2 = .00$. Nor was there a significant Perspective x Consistency x Coordination interaction $F(1,101)= .16$, $p= .69$ $\eta p^2 = .00$.

Appendix I: Post-hoc power analyses

For this thesis, the sample sizes were calculated based on power analyses for t-tests based on the between subjects' factor (Coordination, Similarity or Predictability) in the mixed-model ANOVA. However, multiple studies were ultimately underpowered following the exclusion criteria, participants with less than 67% accuracy in any of the four trial conditions were excluded. Therefore, a post-hoc power simulation of the variable effects and interactions for Accuracy was conducted in R. The results are displayed in Table xii.

Table xii: Post-hoc simulated power for the variable effects and interactions for Accuracy in the three-way mixed-model repeated measures ANOVA Studies

	1	***2***	***4***	***5***	***6***	***8***
Manipulation	9.10	6.80	42.68	12.38	5.00	16.67
Perspective	99.81	99.29	26.26	75.37	99.99	26.26
Manipulation x Perspective	26.26	14.28	7.26	42.25	42.25	7.26
Consistency	100.00	100.00	100.00	100.00	100.00	100.00
Manipulation x Consistency	26.26	42.25	99.81	5.00	14.28	59.69
Perspective x Consistency	26.26	5.00	7.26	14.28	99.96	7.25
Manipulation x Perspective x Consistency	26.26	5.00	26.26	94.16	75.37	26.26

However, the power simulation fails to provide any further insight into the Consistency effect, which was significant in all Studies. As a result, a mini-meta-analysis was conducted to compare the consistency effect sizes between Studies 1 to 9. Although the power simulation only used Accuracy, the mini-meta-analysis analysed both Reaction Times and Accuracy. For the mini-meta-analysis, the raw data was gathered from the consistency effect and split within each study by Perspective (Own and Other). The data was then categorised for sub-analyses

using between-subjects factors and additional coding such as whether the Coordination task used Music or Beat based stimuli. How the studies were coded for the mini-meta-analysis is shown in Table xiii. The mini-meta-analysis sought to investigate the influence of the Study manipulations on the consistency effect.

Table xii: The codes for each Study inputted into the mini-meta-analysis

	Study Size Self	Study Size Other	Manipulation	Coordination	Music or Beats	Similarity	Predictability
Study 1	73	73	Synchrony	Synchrony	Synchrony Music	-	-
	74	74	Asynchrony	Asynchrony	Asynchrony Music	-	-
Study 2	48	48	Synchrony	Synchrony	Synchrony Music	-	-
	41	41	Asynchrony	Asynchrony	Asynchrony Music	-	-
Study 3	12	12	Synchrony	Synchrony	Synchrony Music	-	-
	14	14	Asynchrony	Asynchrony	Asynchrony Music	-	-
	13	13	Control	Control	-	-	-
Study 4	42	42	High Similarity	-	-	High	-
	46	46	Low Similarity	-	-	Low	-
Study 5	39	39	High Similarity	-	-	High	-
	59	59	Low Similarity	-	-	Low	-
Study 6	17	17	High Similarity	-	-	High	-
	20	20	Low Similarity	-	-	Low	-
Study 7	49	49	High Similarity Synchrony	Synchrony	Synchrony Music	High	-
	54	54	Low Similarity Synchrony	Synchrony	Synchrony Music	Low	-

	52	52	High Similarity Asynchrony	Asynchrony	Asynchrony Music	High	-
	42	42	Low Similarity Asynchrony	Asynchrony	Asynchrony Music	Low	-
Study 8	39	39	Predictable Synchrony	-	Synchrony Beats		Predictable
	36	36	Unpredictable Synchrony	-	-		Unpredictable
Study 9	31	31	Synchrony	-	Synchrony Beats		Predictable
	37	37	Leading	-	-		Predictable
	32	32	Following	-	-		Predictable
	36	36	Asynchrony	-	Asynchrony Beats		Unpredictable

Accuracy

The overall effect of Consistency across all 9 Studies, between the Own and Other Perspective conditions, was not significant (Z = -1.45, p= .15). The differences between the effect sizes by the Study, split by Perspective conditions are illustrated in Figure iii.

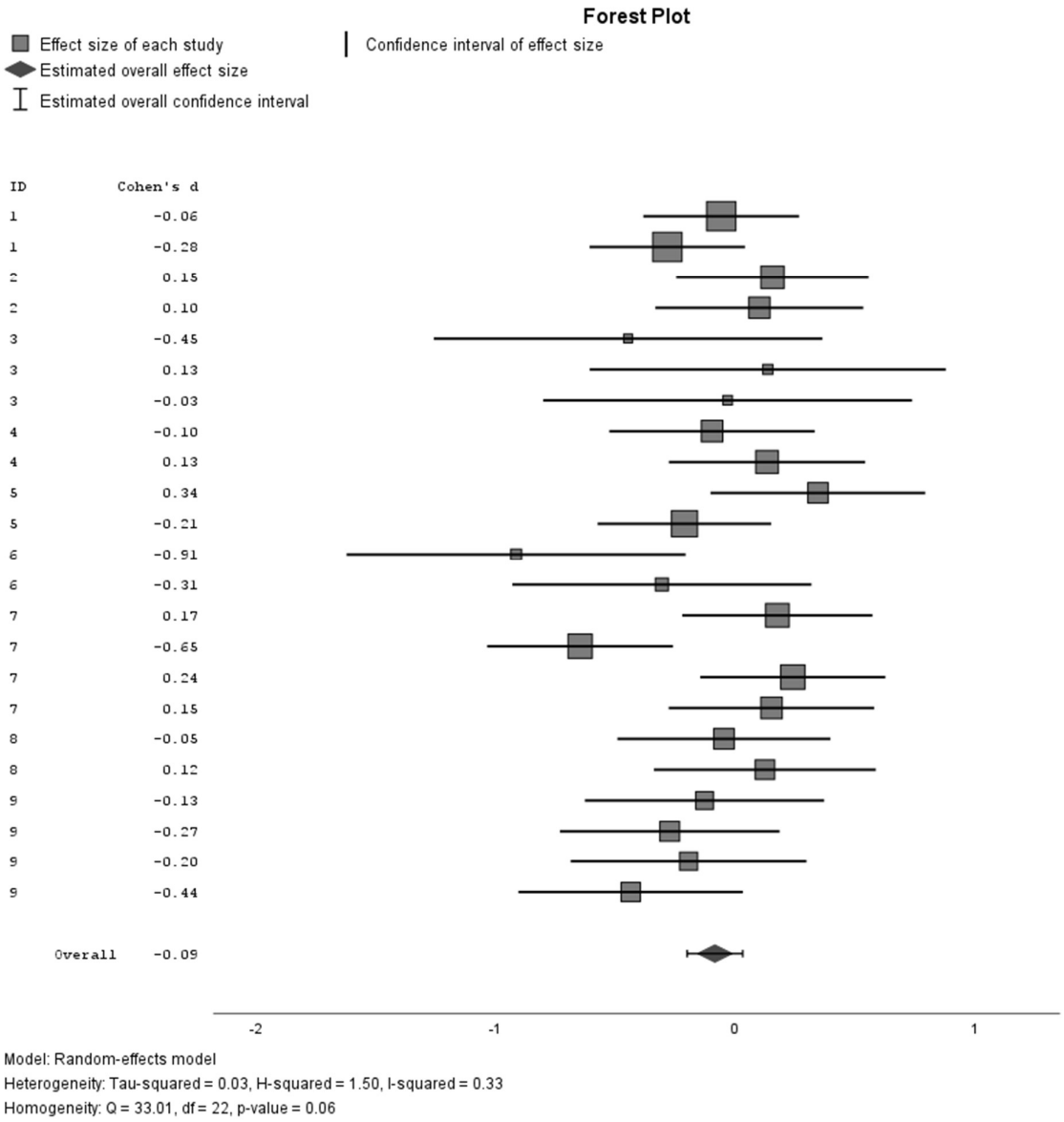


Figure iii: Forest Plot illustrating the estimated effect sizes for Consistency in each Perspective condition for Accuracy

The first sub-group analysis investigated Coordination, prioritising Studies 1-3 and 7. Neither Asynchrony ($Z = .304$, $p = .76$) nor Synchrony ($Z = -.80$, $p = .43$) significantly impacted the size of the Consistency effect in either Perspective condition. The Control condition of Study 3 was also considered but not found to result in a significant difference ($Z = .08$, $p = .93$). The differences in effect sizes between the relevant Studies, grouped by Coordination are illustrated in Figure iv.

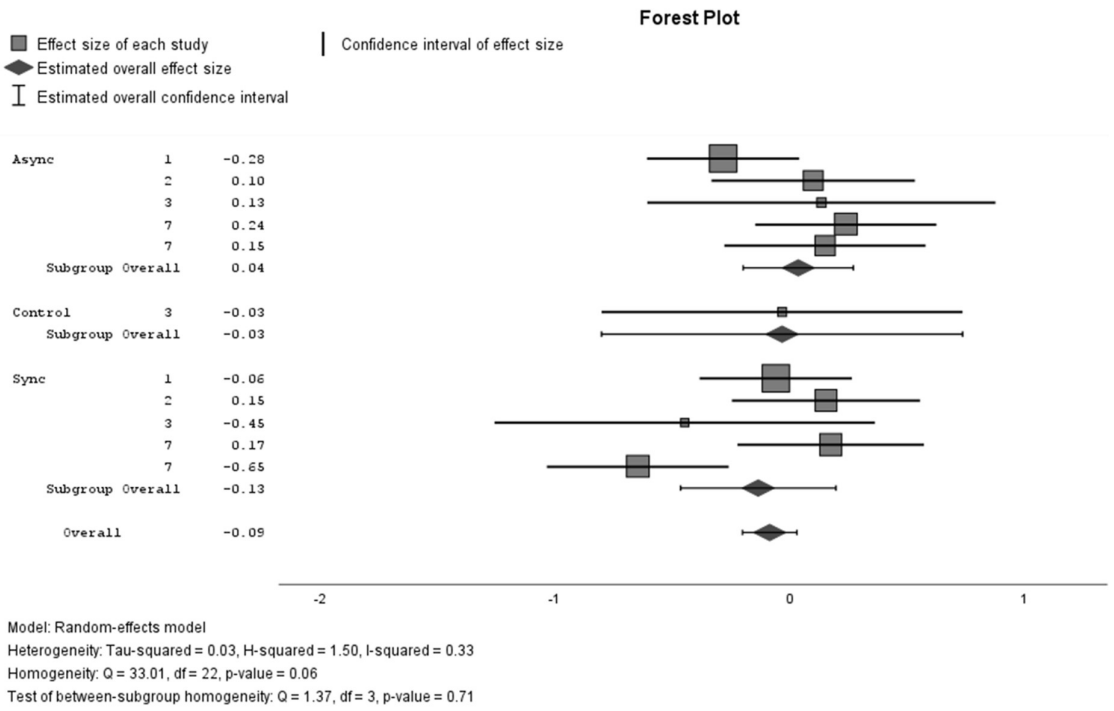


Figure iv: Forest Plot illustrating the estimated effect sizes grouped by Coordination, Accuracy measurements

The primary between-subjects factor of Chapter 3 was Similarity. Sub-group analysis revealed that neither High (Z= .10, p= .92) nor Low Similarity (Z= -1.12, p= .26) significantly impacted the size of the Consistency effect in either Perspective condition. The differences in effect sizes between the relevant Studies, grouped by Similarity are illustrated in Figure v.

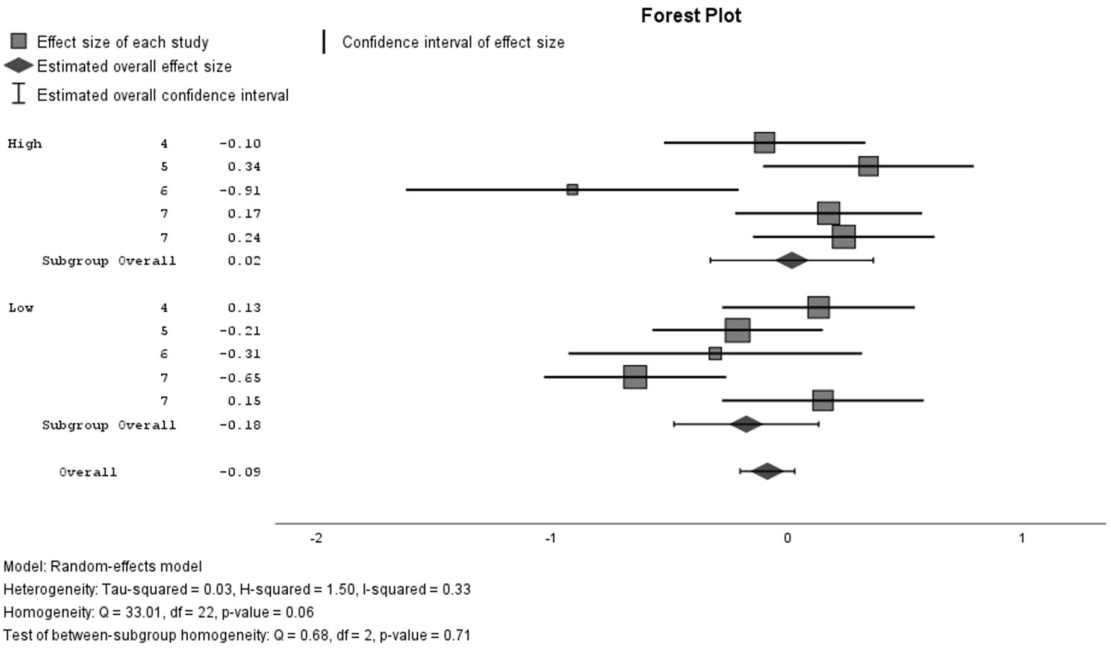


Figure v: Forest Plot illustrating the estimated effect sizes grouped by Similarity, Accuracy measurements

The primary between-subjects factor of Chapter 4 was Prediction. Sub-group analysis revealed that neither Predictable (*Z*= -1.33, *p*= .183) nor Unpredictable (*Z*= -.58, *p*= .58) significantly impacted the size of the Consistency effect in either Perspective condition. The differences in effect sizes between the relevant Studies, grouped by Prediction are illustrated in Figure vi.

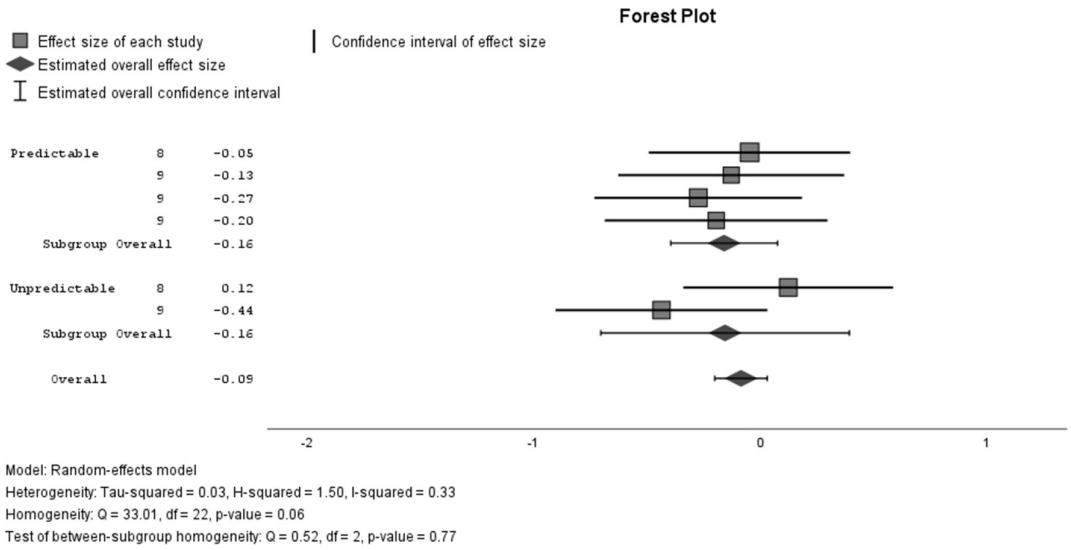


Figure vi: Forest Plot illustrating the estimated effect sizes grouped by Prediction, Accuracy measurements

A further concern of the overall investigation for this thesis was that the Synchrony findings from Chapter 2, did not replicate in Chapter 4. This was attributed to the methodological design change in the Coordination task, wherein the auditory cues to tap changed from music to a beat track. A sub-group analysis was conducted to further support this explanation, comparing the Coordination and Audio. For Synchrony, neither Beats (Z = -.50, p = .62) nor Music (Z = -.80, p = .43) significantly impacted the size of the Consistency effect between Perspectives. For Asynchrony, neither Beats (Z = -1.83, p = .07) nor Music (Z = .30, p = .76) significantly impacted the size of the Consistency effect between Perspectives

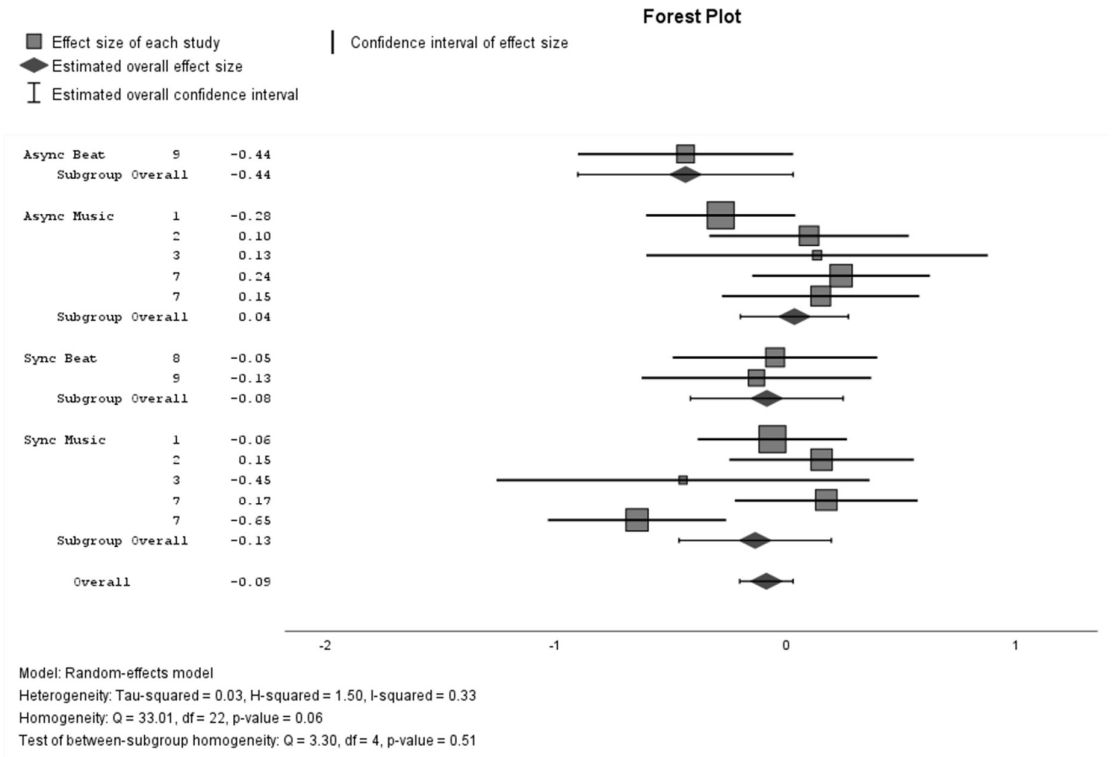


Figure vii: Forest Plot illustrating the estimated effect sizes grouped by Coordination and Audio, Accuracy measurements

Reaction Times

The overall effect of Consistency across all 9 Studies, between the Own and Other Perspective conditions, was significant ($Z = 7.53$, $p < .001$). The differences between the effect sizes by the Study, split by Perspective conditions are illustrated in Figure viii.

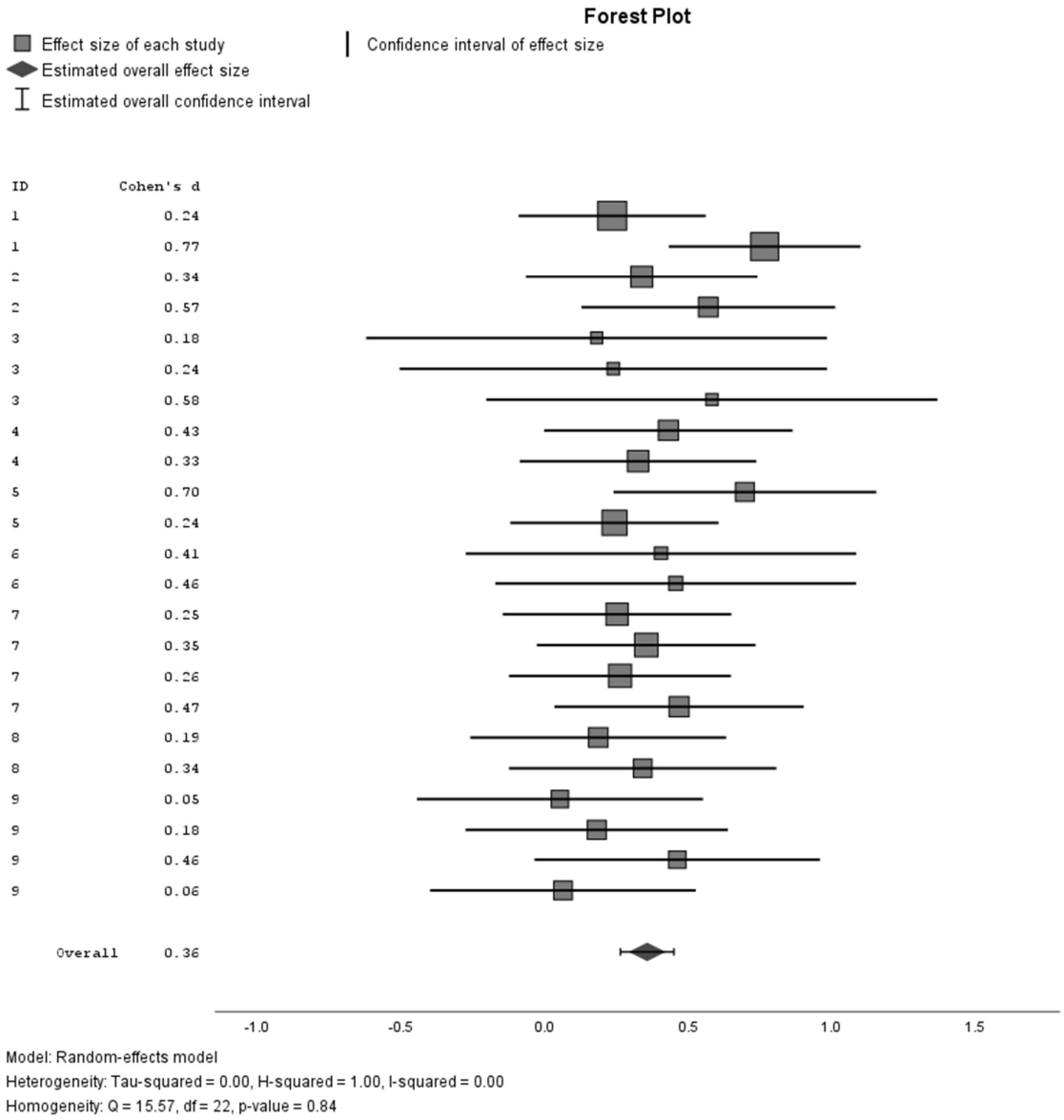


Figure viii: Forest Plot illustrating the estimated effect sizes for Consistency in each Perspective condition for Reaction Times

The first sub-group analysis investigated Coordination, prioritising Studies 1-3 and 7. Both resulted in a significant difference to the size of the Consistency effect between Perspective conditions. With Asynchrony ($Z = 4.54$, $p < .001$) causing slightly larger differences between Own and Other Consistency judgements than Synchrony ($Z = 3.07$, $p < .001$). The Control condition of Study 3 was also considered but not found to result in a significant difference (Z

= 1.46, p = .15). differences in effect sizes between the relevant Studies, grouped by Coordination are illustrated in Figure ix.

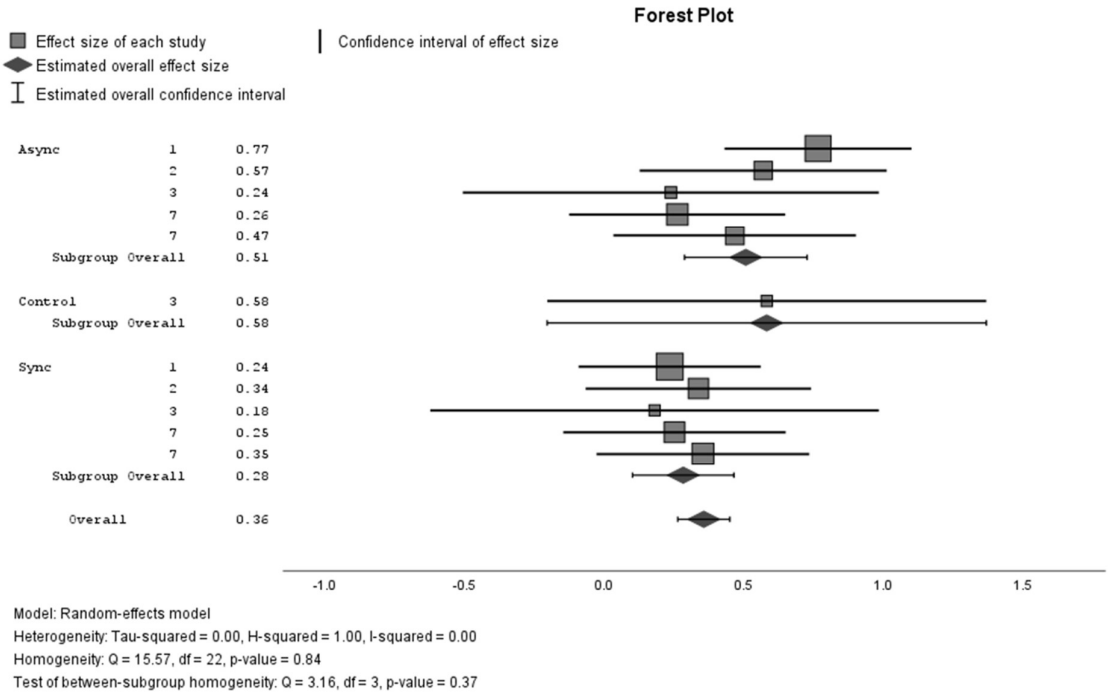


Figure ix: Forest Plot illustrating the estimated effect sizes grouped by Coordination, Reaction Times measurements

The primary between-subjects factor of Chapter 3 was Similarity. Sub-group analysis revealed that both High (Z = 3.85, p<.001) and Low (Z = 3.64, p<.001) Similarity had significant differences for the Consistency effect size between Perspective judgements. The differences in effect sizes between the relevant Studies, grouped by Similarity are illustrated in Figure x.

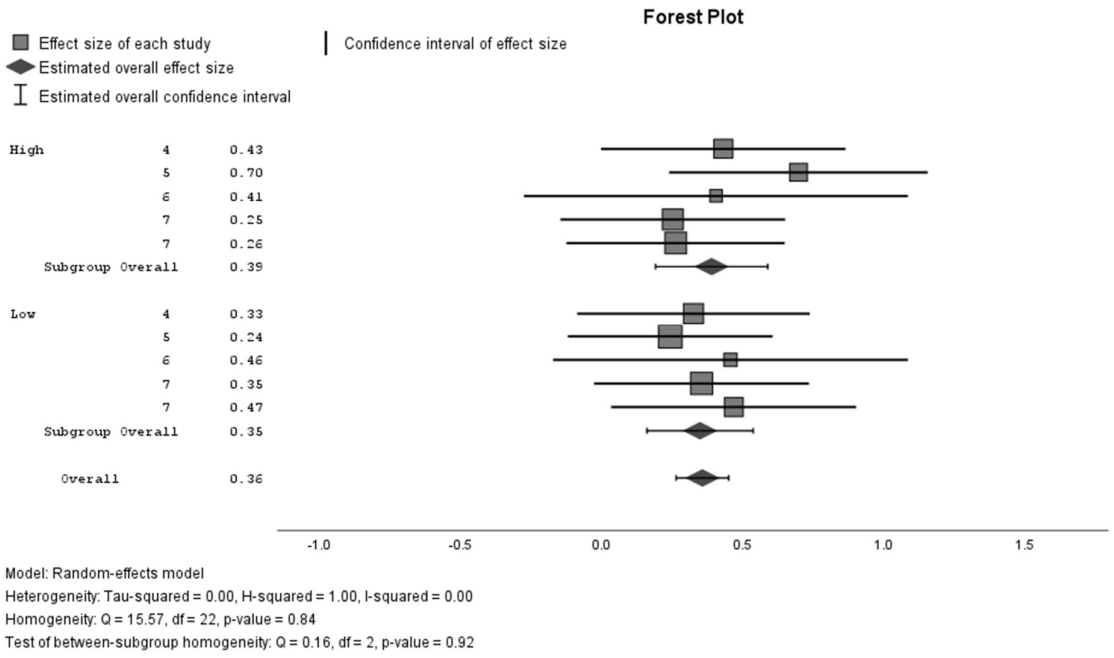


Figure x: Forest Plot illustrating the estimated effect sizes grouped by Similarity, Reaction Times measure.

The primary between-subjects factor of Chapter 4 was Prediction. Sub-group analysis revealed that neither Predictable (Z= 1.81, p= .07) nor Unpredictable (Z= 1.21, p= .23) significantly impacted the size of the Consistency effect in either Perspective condition. The differences in effect sizes between the relevant Studies, grouped by Prediction are illustrated in Figure xi.

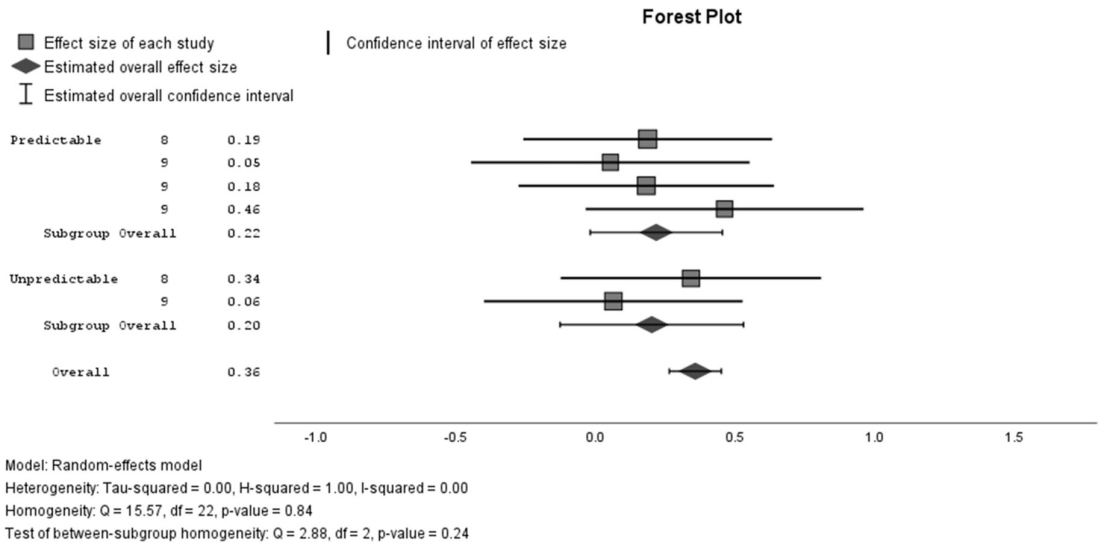


Figure x: Forest Plot illustrating the estimated effect sizes grouped by Prediction, Reaction Times measure.

The final sub-analysis of the mini-meta-analysis compared Coordination and Audio. For Asynchrony, the beat track did not have a significant impact on the size of the Consistency effect (Z = .27, p = .78) but the music track did (Z = 4.54, p<.001). This was reflected in the Synchrony Coordination group, the beat track did not have a significant impact on the size of the Consistency effect (Z = .76, p = .45) but the music track did (Z = 3.07, p= .002).