ALIGNING BODIES AND MINDS: NEW INSIGHTS ABOUT SYNCHRONY'S EFFECTS ON CREATIVE THINKING, COHESION, AND POSITIVE AFFECT

BY

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Abstract

Researchers conjecture that rituals have been prevalent in human activities for millennia due to tacit evolutionary functions of solidarity and cooperation. A key element of ritualistic behaviours is *synchrony*, defined as the matching of actions in time with others. Synchrony has been associated with a range of phenomena, including increased affiliation, connectedness, and cooperation among group members. However, there have been a number of failed replications of key studies. Furthermore, synchrony research has focused mainly on social and affective responses. Synchrony's effects on cognitive processes remain largely unexamined, even though synchronous actions require social cognition. In this thesis, I investigate the link between synchrony and creative thinking, a basic and distinctively human cognitive process. This thesis reports four empirical studies conducted to investigate two main aims: (1) synthesise existing synchrony literature to determine synchrony's overall effect on previously studied outcomes; and (2) investigate the relationship between synchrony and creative thinking. The focus on creativity is theoretically relevant because both sociological speculations about synchrony's role on cultural conformity and real-world observations on reduced decision quality in highly cohesive groups (e.g., groupthink) suggest that synchrony may have detrimental effects on creativity. To address the first aim, a meta-analysis (Study 1) of experimentally manipulated synchrony studies showed that synchrony was positively associated (small to medium effect sizes) with prosocial behaviour, social bonding perceptions, partner cognition, and positive affect. Three experimental studies were conducted to address the second aim. Study 2 investigated the direct association between synchrony and two components of creative thinking – convergent thinking (i.e., synthesis of ideas toward a single creative solution) and divergent thinking (i.e., generation of multiple alternative ideas) – and aimed to replicate shared intentionality (i.e., shared goal/purpose) on positive social and affective responses. Shared intentionality has been argued as one of the main mechanisms amplifying synchrony's positive social effects. In this study, I found that synchrony impaired convergent thinking when paired with shared intentionality, but I did not find support for a statistically significant effect of synchrony on divergent thinking. Additionally, I replicated synchrony's positive social and affective effects. Broadening the scope, ritualistic behaviours in real-world contexts often vary in synchronicity and physical intensity simultaneously. Intensity has been shown to increase social bonding, well-

being, and certain cognitive processes; therefore, it is important to study the separate effects of synchrony and intensity on these outcomes. To do so, I conducted a naturalistic field study (Study 3) of group exercises varying in synchrony and intensity, and Study 4 examined the same associations with a controlled experiment. I found that synchrony impaired divergent thinking, but high intensity facilitated divergent and convergent thinking. Synchrony paired with shared intentionality as well as high intensity increased cohesion among participants. Moreover, performing movements together regardless of synchronicity may be sufficient to increase positive affect. My thesis offers a novel theoretical and empirical contribution to knowledge by revealing that although synchronised actions may have been evolutionarily adaptive for prosocial behaviours, cohesion, and well-being, synchrony also appears to inhibit cognitive processes such as creative thinking.

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Statement of Authorship

The three empirical chapters in this thesis (Chapter 3, 4, and 5) were written with the intention that each be submitted for publication. Hence, each empirical chapter was written as standalone research manuscripts, each with an introduction, method, results, and discussion section.

I am the primary author on each manuscript. With the guidance of my supervisors, I developed the study concepts and designs, conducted the data collection and analysed the results, and wrote the full manuscripts. Study 1 in Chapter 3 (Mogan, Fischer, & Bulbulia, 2017) has been published by the Journal of Experimental Social Psychology. The manuscript included in the thesis is the accepted version of the manuscript with permission from the journal. A revised version of Study 2 (Chapter 4) has been submitted for review to Frontiers in Psychology. Studies 3 and 4 (Chapter 5) have been submitted for review to Religion, Brain and Behavior.

Chapter 1

Thesis overview

Overview

Rituals are a fundamental part of human life and have been prevalent for centuries. Drawings in caves and on rocks depicting people dancing in groups provide evidence that music and dance have been present in human cultures since prehistoric times. Some of these rituals have remained the same since their conception, while others have taken new forms, and others have been formed anew. Examples of these rituals range from fire-walking ceremonies and chanting for religious purposes, to marching, and to dancing and singing.

What are rituals and why do they still exist? Hobson, Schroeder, Risen, Xygalatas, and Inzlicht (2018)defined a ritual as "predefined sequences characterised by rigidity, formality, and repetition that are embedded in a larger system of symbolism and meaning, but contain elements that lack direct instrumental purpose" (p. 2). Although rituals apparently lack direct instrumental purpose, anthropologists, sociologists, and psychologists argue that rituals have tacit evolutionary benefits (Durkheim, 1912/1995; Ehrenreich, 2006; Hagen & Bryant, 2003; Haidt, Seder, & Kesebir, 2008; Henrich, 2015). Researchers conjectured that rituals have been advantageous for human populations due to its cultural adaptations for social and group interactions, and cooperation amongst group members (Watson-Jones & Legare, 2016), especially within larger groups (Dunbar, 2010; Dunbar & Shultz, 2010). To the extent that these arguments are correct, this may partly explain why rituals have existed for millennia and have been prevalent universally.

Hobson and colleagues (2018) recently proposed a framework for the psychological functions of rituals. They suggested that rituals function to regulate three psychological states – social connection to others, emotions, and the performance of goal states. The different features of rituals regulate these three psychological states through bottom-up and top-down processing. The physical performance of actions in a ritual lead to bottom-up processing (e.g., processing of movement perceptions and attention). The psychological features of rituals lead to top-down processing (e.g., processing of the appraisals and interpretations of the rituals).

Similar to the claims of other scholars (e.g., McNeill, 1995; Turner, 1969), Hobson et al. (2018) suggested that rituals function to regulate social connections amongst group members. The display of actions and the meaning behind the actions performed during rituals symbolise cooperation, collaboration, and solidarity amongst members, especially in large social groups (Atran & Henrich, 2010). Additionally, rituals also function to transmit, reinforce, and maintain cultural/social norms (Lienard & Boyer, 2006; Rossano, 2012). According to Hobson et al. (2018), rituals are a way to "regulate social anti-structure and formalised social order" (p. 11). Rituals motivate and remind the group or community members to behave in ways that are consistent with group norms. This is achieved through coordinated actions and signalling the importance of sharing the group's collective meaning, which also fosters stronger social connections amongst group members.

A second function of rituals is to regulate emotions (Hobson et al., 2018). The physical features of rituals (i.e., the performance of a sequence of rigid and repetitive actions) act as a distraction from negative and anxious feelings by swamping an individual's working memory (Boyer & Liénard, 2006; Lienard & Boyer, 2006). Rituals alleviate anxiety, stress, and negative emotions by focusing the individual's attention on the successful completion of a structured sequence of actions (be it movements or vocalisations) which blocks unnecessary and unwanted negative thoughts and emotions.

The third function of rituals according to Hobson and colleagues (2018) is to regulate the performance of goal states. According to the authors, rituals enhance goal pursuits by increasing feelings of personal involvement typically through the experience of performing repetitive and sequenced actions, and by bringing attention to the goal of the ritual context (i.e., the reason for the ritual).

In this thesis, I focus on the physical features of rituals – *ritualised behaviours* – which lead to psychological effects caused by bottom-up processing. Ritualised behaviour is a "defined way of organising a limited range of actions" (Boyer & Lienard, 2006, p. 2). Ritualised behaviours are a central element of rituals, but are by no means found in all rituals (Lienard & Boyer, 2006). Specifically, I focus on collective ritualised behaviours with synchronised body movement. Synchrony – the matching of behaviour in time with others (Hove & Risen, 2009) – is one of the key physical features of rituals, but can often occur outside or without a ritual as well. It is possible that synchronous actions within rituals evolved as an adaptive trait due to its benefits to the group members who practice it. Systemic and effective coordination was probably

integral and beneficial to the survival of some populations. Synchrony is argued to foster a sense of belonging and cooperation among members of the group, supporting the claim of it being an adaptive function. Performing movements and vocalisations at the same time with members of the group is a signal of cooperation and group solidarity (Reddish, Fischer, & Bulbulia, 2013; Wiltermuth & Heath, 2009). For instance, an army unit where every member is marching in complete synchrony with each other is perceived as united and cooperative because each member is seemingly in tune with each other like a well-oiled machine, and therefore perceived as strong. However, an army unit with soldiers not marching in synchrony is perceived as not united and disorganised, and therefore vulnerable. Hence, synchronised actions signal coalition, strength, and solidarity to in-group members and to outsiders observing the synchronised actions (Fessler & Holbrook, 2014; Hagen & Bryant, 2003).

In today's day and age, synchronised actions are still used to signal coalition and solidarity amongst in-group members. For instance, some organisations have capitalised on these positive effects of synchronised actions by creating team-building activities, chants (e.g., Walmart staff begin their work day every morning with the Walmart chant; Kluver, Frazier, & Haidt, 2014), and group exercises (e.g., Zumba classes) which use synchronised actions to boost team morale.

Synchrony has often been praised for its positive social and affective effects. However, synchrony may also have potential detrimental outcomes. While synchronous actions may be beneficial in some circumstances (i.e., to induce cohesion, solidarity, and rigid social norms), synchrony may not be ideal in other circumstances which require more individuality rather than convergence to the norm. One of the aforementioned functions of rituals was the regulation of social connections through the transmission and maintenance of social norms. The need for stronger social bonds, commitment, and cooperation amongst group members may also serve to decrease individual differences and rein in members who defy the group's social norms. This indicates that one of the core functions of rituals, with regard to the regulation of social connections, is to manage conflicts and maintain cohesion by decreasing individual differences. If synchrony is one of the core mechanisms of collective rituals, then synchronous actions could act to dampen individuality as well.

In line with this reasoning, synchrony has been shown to elicit potential detrimental outcomes. Some researchers have found that synchrony leads to more behavioural conformity (Dong, Dai, & Wyer, 2015), destructive obedience (Wiltermuth,

2012a), and compliance to engage in aggressive behaviours (Wiltermuth, 2012b). These studies provide some initial evidence that conformity to normative behaviours is not always advantageous. Real-world examples of these phenomena include hazing behaviour, displays of aggressive behaviours among fans of sports clubs, and cult behaviour.

Aside from a handful of studies, synchrony researchers have often focused on synchrony's behavioural, social, and affective outcomes. Very little is known about synchrony's effects on cognitive processes. One cognitive process that is highly valued in a range of institutions, but is still one of the least understood mental processes (Steinberg et al., 1997), is creativity. Creativity is the ability to produce ideas or responses which are new, appropriate and useful to problems (Amabile, 1983). Creativity is part of what makes us human, and what sets us apart from other mammals. As Albert Einstein (1929) said,

> "Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world" (p. 117).

Creativity is one of the most common ways of expressing individuality (Bechtoldt, Choi, & Nijstad, 2012; Dollinger, Burke, & Gump, 2007). Following from the argument that one of the core functions of the evolution of collective rituals is to decrease individual differences for norm adherence, I speculate that synchronous actions could very likely act to reduce creativity by dampening individuality, in a similar way to synchrony affecting positive social and affective outcomes (i.e., increased feelings of solidarity, cohesion, and coalition).

Real-world observations on highly cohesive groups having poorer decision-making quality (i.e., the groupthink phenomenon; Janis, 1982), along with synchrony's potential role in cultural conformity, suggest that synchrony may in fact have damaging effects on creativity. Synchrony induces both cohesion and behavioural conformity potentially through perceptions of similarity between participating members (Dong et al., 2015; Reddish et al., 2013). These perceptions of similarity potentially induce more convergence and conformity in thought processes and shared mental states (Baimel, Severson, Baron, & Birch, 2015) through shared attention, which stifle the uniqueness and individuality of a person, and thereby impair certain aspects of creativity. The association between synchronous actions and creative thinking has not been tested, and this thesis aims to address this gap in the literature.

Thesis Aims and Outline

The two main aims of this thesis can be summarised with two key words – synthesise and investigate. The first aim of this thesis is to *synthesise* the existing literature on experimental paradigms that manipulate synchrony to determine the overall effect of synchronous actions on prosocial behaviours, social bonding perceptions, positive affect, and cognitive processes. Synchronous actions have been found to increase prosocial behaviours, social bonding perceptions, and positive affect. They have also been shown to affect some cognitive processes. However, there are studies (including some unpublished studies) which have not been able to replicate some key aspects of synchrony's positive social and affective effects. An important part of scientific research is to replicate and reproduce effects from other experimental studies.

In addition, since the boom of synchrony research over the past decade, research in this area has focused largely on prosocial behaviours, social perceptions, and affective responses. Very few empirical studies have investigated synchrony's effects on cognitive processes. Specifically, no study to date has examined synchrony's effect on creative thinking. Therefore, the second aim of this thesis is to *investigate* the relationship between synchrony and creative thinking, to address this gap in the synchrony literature.

This thesis presents six chapters with four empirical studies. To outline the relevant research to this thesis, Chapter 2 provides an overview and summary of the literature on synchrony and creative thinking. In this chapter, I offer hypotheses for why synchronous actions may affect creative thinking. There is much speculation with regard to the theoretical mechanisms by which synchrony has an effect on prosocial and affective responses. I discuss the different mechanisms that are pertinent to this thesis in the discussion in Chapter 6.

Following Chapter 2, I present three empirical chapters using a combination of three methodologies to examine synchrony's effects on cognitive processes, perceptions of social bonding, and affective responses. The three empirical chapters have either been published (Chapter 3), or have been submitted for publication (Chapters 4 and 5).

Chapter 3 seeks to address the first aim of the thesis by reporting a meta-analysis that systematically reviews experimentally manipulated synchronous movements and vocalisation.

Chapters 4 and 5 seek to address the second aim of the thesis. Chapter 4 examines the direct effects of synchronous movements on creative thinking using an established experimental paradigm. This study (Study 2) also attempts to replicate synchrony's positive effects on social and affective responses.

Chapter 5 broadens the scope. Performing synchronous actions are a physical activity that do not typically occur in isolation. In real-world contexts, ritualistic behaviours that involve physical activities often vary in synchronicity, but also in physical intensity. Physical intensity has been shown to elicit effects on cognitive processes, as well as social and affective responses. Hence, it is beneficial to investigate the separate effects of synchrony and physical intensity on these outcomes. Chapter 5 seeks to investigate the effects of both synchrony and physical intensity on creative thinking, cohesion, and positive affect with two studies. First, to provide more ecological validity to the investigation, Study 3 presents a field study using naturally occurring synchronous movements with varied physical intensity levels (i.e., using different group exercises). Second, to control for some methodological limitations in the field study, Study 4 presents an investigation on creative thinking, cohesion, and positive affect with a controlled experimental paradigm of synchronous movements which vary in levels of physical intensity.

Chapter 6 is the final chapter which summarises and synthesises the evidence from all four empirical studies presented in Chapters 3, 4, and 5. In this chapter, I present a comprehensive summary of all the main findings. Next, I discuss theoretical mechanisms that potentially explain how synchronous actions affect creative thinking, cohesion, and positive affect. Then, I provide some context to the findings with practical implications. Finally, I address some limitations of my work and suggest future avenues for research.

Chapter 2

General Introduction

This thesis aims to synthesise synchrony's effects on behavioural, social, affective, and cognitive outcomes, as well as to investigate synchrony's direct effect on creative thinking. A secondary aim is to replicate the positive social and affective effects of synchronous actions. In this chapter, I will present a brief overview of the previous synchrony literature and proposed effects on prosocial behaviours, perceptions of social bonding, affective responses, and cognitive processes. Next, I will present the creative thinking literature, and finally propose the thesis's novel contribution of how synchrony might affect creative thinking.

Synchrony

Synchrony can be defined as the matching of rhythmic behaviours in time with others (Hove & Risen, 2009). Synchrony is ubiquitous and manifests in a myriad of ways in human life. Examples of synchronous actions range from intrapersonal synchronisation (e.g., pacemaker cells in the heart and circadian rhythms) to interpersonal or interactional synchronisation (e.g., a choir singing together; a group of dancers dancing together; an army of solders marching together; synchronised clapping by audience members). Synchrony is not just restricted to human beings. From fireflies flashing in unison to frogs croaking in harmony, and to birds flocking in formation, the animal kingdom displays scores of synchronisation amongst the different species. That synchronisation is prevalent with all beings, shows the importance of this potentially evolutionary trait in all living beings (Clayton, Sager, & Will, 2004).

It is important to briefly distinguish between synchrony, and another type of interpersonal interaction – mimicry. Mimicry has some similarities to synchrony and some important differences. Both synchrony and mimicry involve imitation of another's actions. Synchrony requires conscious effort from an individual to perform the same actions as another, and the actions are temporally matched (i.e., the simultaneous movement of actions in time with another). On the other hand, mimicry is often automatic, unconscious, and not temporally matched (Chartrand & Bargh, 1999; see Chartrand & van Baaren, 2009, for a review of human mimicry). This distinction

crucially sets synchrony apart as a form of joint coordination (Marsh, Richardson, & Schmidt, 2009). Furthermore, synchrony can occur with dyads or in groups of three and more. Mimicry, on the other hand, typically occurs only in dyadic social interactions. This thesis will focus on the conscious matching of movements performed in groups of three and more, and hence will only focus on synchrony.

Two Forms of Synchrony

Synchronous actions can be categorised as either frequency-locked or phase-locked (Clayton et al., 2004). Frequency-locked synchrony occurs when actions are performed with the same frequency (i.e., the same speed), as when two pendulums swing from the same height and at the same speed. An example of frequency-locked human synchronisation between two individuals occurs when both person A and person B raise their hands above their heads together at the same time and speed, and bring their hands down together at the same time and speed (e.g., marching) (see image 'a' in Figure 2.1). When the same action is performed at the same time, the actions are said to be in synchrony. When the same action is performed by both individuals but not at the same time (i.e., not frequency-locked), the actions are said to be in asynchrony. An example of this occurs when both person A and person B raise their hands above their heads and bring their hands down, but person B moves at a faster or slower speed than person A (see image 'b' in Figure 2.1).

Phase-locked synchrony occurs when actions are performed on the same plane or dimension. When actions are frequency-locked and phase-locked, person A and person B perform the same action at the same time and speed (i.e., synchrony and in-phase). When actions are frequency-locked but in anti-phase, the same actions are performed at the same time and speed but in the opposite direction. An example of this occurs when person A has the hands raised and person B has the hands down (see image 'c' in Figure 2.1).

For the purposes of this thesis, I define and operationalise synchrony in terms of frequency-locked behaviour. Synchronous actions are behaviours that are performed at the same time and speed, and asynchronous actions are behaviours performed at different speeds.

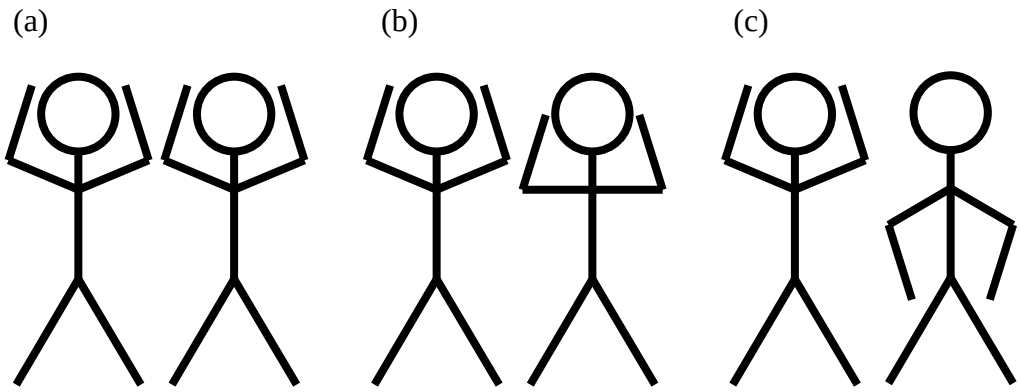


Figure 2.1. Examples of actions which are in (a) synchrony/frequency-locked, (b) asynchrony/not frequency-locked, and (c) anti-phase synchrony.

Evidence of Synchrony Effects

Evidence for synchronous movements and vocalisations are deeply rooted in the human record, particularly in the form of music and dance (Reddish et al., 2013). Why have we passed down these culturally universal behaviours from generation to generation for centuries and millenia? As aforementioned, some researchers suggest that synchrony offers some positive evolutionary benefits to group members (Hagen & Bryant, 2003; Henrich, 2015). Empirical evidence has been found to support this conjecture in the form of increased prosocial behaviours (Reddish et al., 2013; Wiltermuth & Heath, 2009), social bonding perceptions (Hove & Risen, 2009; Valdesolo & DeSteno, 2011), positive affect (Tschacher, Rees, & Ramseyer, 2014), and some cognitive processes (Baimel, Birch, & Norenzayan, 2018; Macrae, Duffy, Miles, & Lawrence, 2008). Providing an exhaustive summary of the effects of synchrony on each of these dimensions of response is beyond the scope of this chapter. A systematic empirical review of the synchrony literature along with specific measures is presented in the next chapter, which will also include potential mechanisms that explain synchrony's effects on the dimensions of response (I expand on these mechanisms in Chapter 6). Hence, to provide some context, I will now briefly introduce the overall literature using Hobson and colleagues' (2018) framework for the psychology of rituals as a guide. Only two (i.e., social connections and emotions) of the three regulatory functions they proposed are relevant to the thesis. I describe typical experimental manipulations and some of synchrony's proposed effects below.

Social connection. One argument for the prevalence of synchrony in human activities is that it functions to act as a social glue to foster prosocial responses such as cooperation, solidarity, and social cohesion amongst group members (Launay, Tarr, & Dunbar, 2016; Turner, 1969). This hypothesis has mostly been explored in the field of anthropology (e.g., Durkheim, 1912/1995; Ehrenreich, 2006; McNeill, 1995). It has only been more thoroughly investigated in the field of psychology within the last decade.

Wiltermuth and Heath (2009) provided the first quantitative evidence for synchrony's effects on cooperative behaviour. In three experimental studies, they found that synchronous actions and vocalisations increased cooperation. In their first study, the researchers instructed participants to either walk around a university campus in step (i.e., in synchrony) or walk normally not in step with each other (i.e., not in synchrony). They found that participants who walked in step cooperated more than participants who did not by choosing to cooperate in a subsequent coordination game. In the second and third studies, participants sang and moved cups in time with each other (i.e., synchrony), out of time with each other (i.e., asynchrony), or did not sing or move cups at all (i.e., control). Wiltermuth and Heath found that compared to participants in the asynchrony and control conditions, participants who sang and moved in synchrony with each other chose to cooperate more in the subsequent coordination game (Study 2), and had higher donations to a public goods game that required individual sacrifice for the overall benefit of the group (Study 3).

Since Wiltermuth and Heath's (2009) study, other researchers have also found that synchronous actions increase prosocial behaviours. For example, Valdesolo and DeSteno (2011) showed that participants who experienced synchronised finger tapping with a confederate showed more compassion for the confederate, and more frequently chose to help the confederate, compared to participants who had confederates who did not synchronise the finger tapping with them. Not only have researchers found that these increases in cooperative behaviour after synchronous actions occur within group members (Launay, Dean, & Bailes, 2013; Sullivan, Gagnon, Gammage, & Peters, 2015), Reddish and colleagues (Reddish, Bulbulia, & Fischer, 2014; Reddish, Tong, Jong, Lanman, & Whitehouse, 2016) have also shown that the cooperative effects of synchronous movements extend to members outside the synchronous group as well.

Researchers have also found that performing synchronous movements and vocalisations led to increased social bonding perceptions such as affiliation, rapport,

perceived similarity, entitativity, trust, and cohesion. For instance, Hove and Risen (2009) showed that the more synchronised participants' finger tapping were with the experimenter, the more affiliation they reported toward the experimenter when compared to participants who finger tapped alone or in asynchrony with the experimenter. Participants who rocked chairs in synchrony (Valdesolo, Ouyang, & DeSteno, 2010) and performed arm curls (arm extensions and flexions) in synchrony (Lumsden, Miles, & Macrae, 2014) reported feeling more socially interconnected to their teammate/confederate compared to participants who did not synchronise. Reddish et al. (2013) also found that synchrony increased group cohesion and entitativity (i.e., the extent to which a group is perceived to be a meaningful unit; Campbell, 1958).

Importantly, researchers found that shared intentionality – having a common collaborative goal or understanding (Tomasello, Carpenter, Call, Behne, & Moll, 2005) – amplified synchrony's effect on prosocial responses. Through a series of three well-designed and controlled experiments, Reddish et al. (2013) investigated the positive prosocial effects of synchronous actions and the addition of shared intentionality on cooperative behaviour. They manipulated shared intentionality by providing participants with a shared group goal of maintaining their synchronised body movements with each other. In all three studies, Reddish et al. (2013) found that participants who performed synchronised actions with the addition of the shared group goal (i.e., shared intentionality) cooperated more and reported higher trust, similarity, entitativity, and interdependent self-construal scores compared to the other conditions. The authors explained that by providing group members with a shared purpose to focus on, participants were required to pay more attention to each other to achieve the group goal. This shared joint attention led to more cooperation because it increased the perception that each group member is cooperating (by putting in their own effort to achieve successful synchronisation of movements), which fostered feelings of cohesion and trust.

In summary, synchronous actions and vocalisations increase prosocial behaviours (i.e., cooperation) and social bonding perceptions amongst group members in comparison to asynchronous actions or not performing actions at all. Additionally, shared intentionality plays a vital role in amplifying synchrony's effects. A recent meta-analysis on motor-sensory interpersonal synchrony by Rennung and Göritz (2016) showed that shared intentionality increased prosocial behaviours, but not prosocial attitudes. Perhaps the enhancement effects of shared intentionality are stronger for

behaviours rather than perceptions. Nevertheless, it does not rule out the importance of the addition of shared intentionality in synchrony research.

Emotions. The performance (and successful completion) of repetitive, rigid, and structured coordinated (i.e., synchronous) actions may function to reduce negative emotions and anxious feelings by distracting individuals from distressing emotions and thoughts, as well as fulfilling the need for order to regulate anxious stimuli (Hobson et al., 2018). Hence, performing these synchronous actions provides a sense of emotional stability, thereby reducing negative affect and increasing positive affect.

In line with this, anthropologists and sociologists have often discovered that people reported feeling happier or higher feelings of well-being when they were involved with ritualised behaviours. Emile Durkheim (1912/1995) conjectured on the feelings people had when they came together for gatherings. In his book he coined the term *collective effervescence*, which he explained as follows:

> "The very act of congregating is an exceptionally powerful stimulant. Once the individuals are gathered together, a sort of electricity is generated from their closeness and quickly launches them to an extraordinary height of exaltation" (p. 217).

Researchers have conjectured that synchronised movements and vocalisations in ritualistic behaviours such as playing musical instruments, singing, and dancing are vital to fostering the collective effervescence effect of reported feelings of increased happiness and well-being (Ehrenreich, 2006; McNeill, 1995). A study by Tschacher and colleagues (2014) found that in a dyadic interaction, non-verbal synchronisation of body movements predicted increased positive affect and reduced negative affect. However, most studies on synchronous actions have not found that synchrony per se increases positive affect or feelings of happiness. Some studies have shown that there are no statistically significant differences between synchrony and asynchrony conditions. For instance, Wiltermuth and Heath (Study 1, 2009), and Wiltermuth (2012a) found that ratings on happiness, positive emotions, and negative emotions did not differ whether participants walked in step with the other experimenter/others (synchrony), walked out of step with the experimenter/others (asynchrony), or walked normally with the experimenter/others.

Previous experimental research, then, does not suggest that synchronous actions increase positive affect. However, as Durkheim suggested, it is possible that the mere act of coming together to perform actions with others is sufficient to influence positive and negative affect. If this were the case, then it would not be surprising that previous researchers did not find differences between the synchronous and non-synchronous conditions because participants were performing actions together with others in all conditions. If the act of social gathering affects social emotions, we would expect affective differences when contrasted with conditions in which people perform actions alone. However, based on Hobson et al.'s (2018) conjecture, synchronous actions should reduce negative affect and increase positive affect due to the performance of a structured and repetitive sequence of actions. Hence, asynchronous actions should not elicit the same effects as synchrony. Durkheim and Hobson et al.'s arguments present two contesting premises. On one hand, both synchrony and asynchrony should increase positive affect and decrease negative affect. On the other hand, only synchrony should increase positive affect and decrease negative affect. This calls for further investigation into synchrony's effects on affective responses.

Cognitive functions. Cognitive functions are cerebral activities which include all the processes required for the acquisition and processing of information. These functions encompass a very broad range of categories, including but not limited to, information processing, reaction time, attention span, and memory (Chang, Labban, Gapin, & Etnier, 2012). A lot of attention and cognitive effort is required to coordinate actions in synchrony with another. Being a phenomenon that requires social cognition, it may be the case that synchrony influences other higher-order cognitive aspects as well.

Only a handful of empirical studies have examined the effects synchrony has on cognitive performance. For instance, Macrae and colleagues (2008) found that participants who waved their hands in phase-locked (in-phase) synchrony recalled more words uttered during the experiment than participants who waved in anti-phase with the experimenter. Miles, Nind, Henderson, and Macrae (2010b) found that performing repetitive arm curls in phase-locked synchrony with the confederate facilitated memory recall of self-relevant and other-relevant information compared to arm curls performed in anti-phase with the confederate.

Although these studies showed that synchrony facilitated certain memory performance, both studies compared in-phase with anti-phase synchronous actions, which were both frequency-locked. Asynchronous actions which are not frequency-locked may negatively affect certain cognitive performances due to the added disruption of actions which are not temporally matched. Although Macrae et al. (2008) and Miles et al. (2010b) showed that in-phase synchrony facilitated memory performance compared to anti-phase conditions, it is possible that asynchronous actions disrupt memory performance even further because the participant's attention is split between moving out of time with another and remembering words which is stored in an already swamped working memory (Hobson et al., 2018). Therefore, it is beneficial to investigate whether actions which are frequency-locked and not frequency-locked differ in their effect on cognitive functions. This thesis will do so by comparing synchronous actions to asynchronous actions as well as to control conditions.

Replication Crisis

A core principle of scientific research is replicability or reproducibility (Open Science Collaboration, 2015). We should be able to reproduce similar results if we directly replicated the methods of scientific studies that have empirically examined certain research hypotheses. Within psychological research, this is especially pertinent given that studies which do not find statistically significant results often go unpublished (up until recently).

The aforementioned studies have found that synchrony fosters cooperation, enhances social bonding perceptions and positive affect, as well as facilitates certain cognitive processes. Nonetheless, there are also studies which have not been able to reproduce some key aspects of synchrony's positive effects. For example, a number of studies have not been able to replicate Wiltermuth and Heath's (2009) result that synchronous actions increases cooperation. Schachner and Garvin (2010) directly replicated Wiltermuth and Heath's third study and did not find support that synchrony increases cooperation. After synchronised drumming with an experimenter, Kirschner and Ilari (2014) did not find that children were more cooperative compared to children who drummed alone or drummed along to a metronome beat. Some unpublished theses have also reported results that synchrony did not increase cooperation. In addition, Schachner and Garvin (2010) were not able to replicate some of synchrony's positive

effect on social bonding perceptions in their replication of Wiltermuth and Heath's study. They did not find statistically significant differences between conditions for trust, entitativity, or similarity. Moreover, published studies have also reported similar findings with regard to social bonding effects. Cohen, Mundry, and Kirschner (2013) reported that there were no statistically significant differences between conditions for perceived similarity after synchronised drumming. Lumsden et al. (2014) did not find any statistically significant affiliation differences between conditions in their study. Recently, Baimel et al. (2018) did not find that behavioural synchrony enhanced social cohesion. With the lack of reproducibility, it is essential to synthesise the existing literature in order to examine the overall effects of synchronous actions so far. Hence, the first research question (RQ) of this thesis is:

> RQ 1: What is the overall effect of synchronous actions on prosocial behaviour, perceptions of social bonding, positive affect, and cognitive processes?

Creative Thinking

Creativity is highly valued in most aspects of life (e.g., workforce, education, arts, scientific research, etc.), and is fundamental to human intelligence (Boden, 1998). Creative ability allows for more innovation, flexibility, and improvement (Hennessey & Amabile, 2010; Runco, 2004). Thus, it is beneficial in decision-making and problem-solving processes, as well as the invention of new ideas. Creative thinking is a process by which individuals produce novel or original, and appropriate ideas (Barron, 1955). Novelty or originality refer to something that is new, and appropriate refers to something being useful in a particular context (Amabile, 1982). This thesis will adopt Amabile's (1982) consensual definition of creativity as the operational definition of creativity:

> "A product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are those familiar with the domain in which the product was created or the responses articulated. Thus, creativity can be regarded as the quality of products or responses judged to be creative by appropriate observers, and it can also be regarded as the process by which something so judged is produced" (p. 1001).

Rhodes (1961) distinguished between four aspects of creativity, what he termed the 4Ps of creativity – (1) Person, (2) Process, (3) Press (or Place), and (4) Product. Person refers to the nature of the individual, such as personality traits (e.g., open-mindedness, adventurous; Feist, 1998; George & Zhou, 2002), self-efficacy (Beghetto, 2006), and intellect (Sternberg, 2006). Process refers to the cognitive processes and motivations utilised to generate the creative ideas (see Basadur, Graen, & Green, 1982). Press or place focuses on the interplay between the individual and the environment, in which creativity either thrives or deteriorates (Lopez, Esquivel, & Houtz, 1993; McCoy & Evans, 2002). Product is the actual tangible creative idea or solution that is produced (e.g., an invention, a poem, etc.) and can be measured using creativity tests (i.e., psychometric testing) (see Ma, 2009, for a meta-analytic review of the associated variables of creativity based on these core aspects).

Following Amabile's (1983) suggestion that the creative product is the most appropriate measure of creativity which can be operationally defined, I focus on the creative product in this thesis. Using the creative person, process, or press/place as measures of creativity is not applicable in this thesis because I focus on synchronous actions which are behavioural products, and not person or press/place variables. It will also not be practical due to a huge variation in variables related to these three aspects of creativity. There are numerous personality traits and environmental factors which could affect a person's creativity. Additionally, examining a person's creative process (i.e., their actual thought process or motivation) will either require methods which are not yet feasible (Amabile, 1983), or will require examination at multiple points during the thought process which may hinder the creative process as a whole. Further, the creative person, process, and press/place all lead to the creative product, which is something that can be tangibly examined.

Two Components of Creative Thinking

J.P. Guilford (1967) is considered to be one of the founding fathers of creativity research. In describing creative thinking, he made a distinction between two main components of creative thinking; namely convergent thinking and divergent thinking. Convergent thinking employs logic, knowledge, and accuracy to synthesize pieces of information in order to form a single best accurate solution to a problem (Cropley, 2006). Divergent thinking involves generating multiple alternative solutions to a problem (Baer, 2011; Cropley, 2006). Both convergent and divergent thinking abilities

are used in creative problem-solving. For example, when trying to solve a problem, divergent thinking is usually employed at the start to brainstorm alternative ideas or solutions to the problem. Once the ideas have been produced, the most appropriate idea or solution needs to be picked to best solve the problem, which is when convergent thinking is employed (see Figure 2.2).

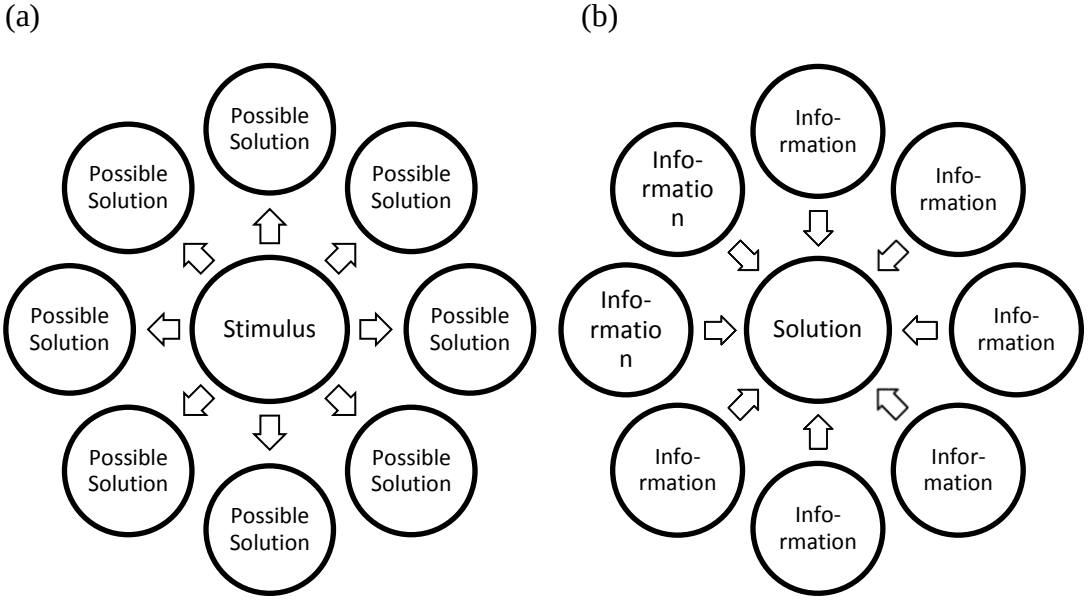


Figure 2.2. Example of (a) divergent thinking, and (b) convergent thinking adapted from Aishwarya.Gudadhe (2015) and Msingh209 (2012).

Amabile (1982) developed the Consensual Assessment Technique (CAT) to assess creative products. The CAT has been described as the 'gold-standard' technique to assessing creative products (Baer & McKool, 2009; Kaufman, Baer, Agars, & Loomis, 2010) because the technique, and herein the validity of the technique, does not depend on a particular theory of creativity. This makes the CAT a practical, accessible, and useful tool for the assessment of creativity. The CAT is a simple technique that asks individuals to create a product (e.g., poems or paintings), and calls for experts in the content domain in question to judge the creativity of the product (e.g., poets evaluate poems, artists evaluate paintings). Experts can evaluate the creative products based on a number of categories (i.e., creativity, novelty/originality, etc.) which are typically rated on a scale. Amabile (1983) recommended that it is most appropriate to have experts in the particular content domain as judges. However, researchers have also employed novice judges to evaluate the creativity of certain products (e.g., Kasof, Chen, Himsel,

& Greenberger, 2007), depending on the goal of the research and the type of creative product being assessed (Kaufman et al., 2010). In addition, although the CAT is an assessment technique which is not dependent on any particular theory of creativity, it can still be used as an assessment tool for other idea-generating creativity measures which may or may not be ascribed to a particular creativity theory (Mouchiroud & Lubart, 2001; Runco & Mraz, 1992), making the CAT a versatile assessment tool. Therefore, the CAT will be used to assess the divergent thinking responses in the empirical chapters (Chapter 4 and 5).

Synchrony and Creative Thinking

Synchrony is a joint coordination process that requires social cognition. Yet, there is limited empirical evidence of synchrony's effects on cognitive processes. This thesis aims to further investigate the effects synchronous actions may have on cognitive processes, specifically creative thinking.

Over a century ago, Emile Durkheim (1912/1995) proposed that coordinated ritualistic behaviours, especially those from music and dance, reflect the conformity of the group members' thought processes:

> "the [ritual] group has an intellectual and moral conformity…everything is common to all. Movements are stereotyped; everybody performs the same ones in the same circumstances; and this conformity of conduct only translates the conformity of thought. Every mind being drawn into the same eddy, the individual type nearly confounds itself with that of the race" (p. 5).

In a similar vein, Liebenberg (2017) argued that the repetitive collective synchronised actions in music and dance have contributed to the facilitation of other aspects of social cognition (i.e., joint attention and shared mental states). Liebenberg suggested that synchronous actions foster cooperation through increased trust, but also through perceived similarity and conformity of group members. This conformity of thought induces conformity to normative group behaviours (i.e., group members behaving in ways that are consistent to group norms), which regulates and stabilises the group's cultural/social norms (Hobson et al., 2018; Lienard & Boyer, 2006). In order to maintain social stability, people who were different and those who did not conform to the wider group activity (i.e., misfits) were likely to be singled out and punished due to

being perceived to be fundamental threats to the maintenance of the otherwise cooperative culture of the group (Boyd & Richerson, 1992). This targeting of misfits enforces a regulatory system which facilitates similarity and conformity to the norm, and inhibits individuality, originality, and divergence of thought processes – all of which are features of creativity – in that group. This potentially occurs by prohibiting the freedom to express one's agency as well as prohibiting the assertion of one's individuality and unique contributions to the group (Dong et al., 2015).

In the present day, an example of how the focus on similarity and conformity amongst group members is displayed is in the form of poor decision-making processes in highly cohesive groups. The groupthink phenomenon is one that plagues many organisations and institutions (Janis, 1982). Landy and Conte (2010) defined groupthink as a "mode of thinking engaged in by people deeply involved in a cohesive group and when group members' desire for agreement overrides their motivation to appraise alternative courses of action realistically" (p. 603). Typically, cohesion amongst group members, especially in the work place, has been positively associated with successful team and task performance, better communication amongst members, and increased well-being of group members (Beal, Cohen, Burke, & McLendon, 2003; Landy & Conte, 2010; Mullen & Copper, 1994). However, highly cohesive groups are more likely to engage in groupthink (Janis, 1982), which is induced by the lack of divergent thinking or alternative viewpoints (Larey & Paulus, 1999). Group members in highly cohesive groups are more likely to conform to the group's normative ideas and decisions even when they disagree with them. This inhibits the generation of alternative ideas and members fail to produce potentially better solutions to a problem (Larey & Paulus, 1999), which leads to impaired performance from the group as a whole (Janis, 1982). The focus on the collective negatively outweighs the benefits of deviating viewpoints, bringing into fruition detrimental decision-making actions that harmfully impact the larger group as a whole. This presents a theoretically novel, interesting, and practical venture in synchrony research. Hence, I pose the following research question:

RQ 2: What is synchrony's effect on creative thinking?'

I hypothesise that synchronous actions will impair divergent thinking, but potentially enhance convergent thinking. Performing synchronous actions requires shared attention between participating members. Shteynberg (2015) stated that individuals share attention when they attend to something together. In order to

continuously perform and maintain the same actions in time with others (i.e., synchrony), an individual is required to focus the attention on stimuli and information coming only from the current context/environment, which is the synchronised movements of participating in-group members. Due to this shared attention amongst in-group members, the group is highly likely to focus only on in-group information and the sharing of information within the group. Shteynberg (2015) explained that when an individual directs more cognitive resources (i.e., attention) to the object, behaviour, or goal which captures the shared attention, it is expected that memories, internalisation of the behaviour, and motivational pursuits of the attended object are greater.

Two studies provide some evidence that synchrony leads to person-centered or group-centered information. Macrae and colleagues (2008) aimed to investigate if interpersonal synchrony could influence person perception and memory recall. Participants were required to wave their hands in time with a metronome beat. During the hand-waving, the experimenter uttered a list of unrelated words to the participant, and at the same time waved her hand either in exact synchrony (in-phase), or in synchrony but anti-phase with the participant, or did not wave her hand at all. After the movement task, the experimenter left the room. Participants were asked to recall as many of the words as they could, and to select a photograph of the experimenter who hand-waved with them from three photographs. The researchers found that participants remembered more words and were better able to recognise the experimenter when the hand-waving was in exact synchrony (in-phase) compared to anti-phase or the control of no joint action. They concluded that exact behavioural synchrony facilitated person perception and incidental memory after a brief social encounter by allowing for person-centered information to be processed in an interdependent manner through shared attention. Two years later, Miles and colleagues (2010b) found that performing repetitive arm curls in synchrony with the confederate facilitated memory recall of self-relevant and other-/confederate-relevant information, but not general memory recall.

These two studies showed that performing synchronous actions with others led to a focus on group-relevant overlapping information. It is likely that this shared attention and focus on group-relevant information facilitate the convergence of thought processes focused only on shared in-group information and restricts alternative information, similar to that of the groupthink phenomenon. Hence, it is highly likely that synchronous actions may facilitate convergent thinking styles rather than divergent thinking styles.

To provide further support, synchrony's effects on convergent and divergent thinking can be explained by synchrony's effects on social bonding perceptions. Performing synchronous movements and vocalisations have been shown to increase perceived similarity and interdependent self-construal (i.e., people's perceptions of their selves as integrated with the relationships with others; Markus & Kitayama, 1991). Shared intentionality has also been shown to amplify these social effects of synchronous actions (Reddish et al., 2013). Tomasello and colleagues (2005) suggested that having shared intentionality allows for more coordinated actions (i.e., synchrony), but also fosters coordinated mental states. Similarly, Baimel et al. (2018) and Liebenberg (2017) argued that synchrony facilitates shared mental states. Synchronous actions are typically uniform and repetitive in nature, especially with actions that are performed in exact synchrony (i.e., frequency-locked actions). These similar actions foster similarly shared mental states through the required shared attention, which evoke the perception of being more similar to another and a closer interdependent self-construal. It is this rigid and repetitive nature of synchrony which could stifle individuality and uniqueness. Therefore, performing synchronous actions could impede divergent thinking. However, synchrony could enhance convergent thinking since convergent thinking requires forming associations between unrelated concepts, which involves the search for similarity across these concepts.

Where To Go From Here?

To my knowledge, no published study has tested the direct relationship between synchrony and creative thinking. The two closest studies found were one of mimicry's association to creative thinking, and one of the association between complementarity and group creativity. Ashton-James and Chartrand (2009) examined the relationship between mimicry and both components of creative thinking. In two experiments, participants were either mimicked or not mimicked by the experimenter during a five-minute conversation. The researchers assessed convergent thinking with a pattern recognition task, and divergent thinking with a novel product labelling task where participants were required to create novel and original labels for three products. They found that having non-verbal behaviours mimicked facilitated convergent thinking, but impaired divergent thinking. Ashton-James and Chartrand (2009) conjectured that the

impairment of divergent thinking could have been through perceptions of similarity between participants who were mimicked and the experimenter.

The second study was by Koudenburg, Postmes, Gordijn, and van Mourik Broekman (2015) who investigated if individual contributions to an activity could elicit more divergent thinking due to the increased sense of solidarity by being given a voice to be heard and valued. In groups of three, participants were required to recite a poem either in synchrony, by taking turns, or independently of each other. The group creativity task was to create a promotion plan for a theatre play of Shakespeare's Romeo and Juliet, which was coded for originality and analysed at the group level. Koudenburg et al. (2015) did not find statistically significant results for coordinated action on divergent thinking, which they attributed to the structure of the groups and group-level creativity. Nevertheless, the results showed a trend that groups in the turn-taking condition generated a higher number of ideas overall and had more original ideas than groups in the synchrony condition. The researchers suggested that group structures which allow for individuals to feel uniquely valued (instead of similar to each other) may foster divergent thinking.

Ashton-James and Chartrand's (2009) study focused on mimicry's influence on creative thinking. Although Koudenburg et al.'s (2015) study is closer to the second aim of this thesis, the focus of their study was on complementary action and not temporally-matched or mismatched actions. Furthermore, as suggested by the Koudenburg and colleagues, the results may have been conflated by group- versus individual-level creativity. Hence, I examine the direct effect synchrony has on individual-level convergent thinking and divergent thinking in this thesis.

The purpose of this chapter was to provide an overview of the literature on synchrony and creative thinking. The next chapter will address the first aim of the thesis, which is to synthesise and provide a more comprehensive review of the existing empirical literature on experimentally manipulated synchronous actions. I investigate the overall effects of synchronous actions on prosocial behaviours, perceptions of social bonding, positive affect, and some cognitive processes.

Chapter 3

Study 1

To be in Synchrony or not? A Meta-analysis of Synchrony's Effects on Behaviour, Perception, Cognition, and Affect

Abstract

We meta-analytically investigated the strength of synchrony on four dimensions of response: (1) prosocial behaviour, (2) perceived social bonding, (3) social cognition, and (4) positive affect. A total of 42 independent studies (N = 4,327) were analysed in which experimentally manipulated synchronous actions were compared to control conditions in healthy non-clinical samples. Our random effects model indicated that synchronous actions affected all four dimensions of response. Synchrony had a medium-sized positive effect on prosocial behaviours, a small-to-medium-sized positive effect on both perceived social bonding and social cognition, and a small-sized positive effect on positive affect. Notably, synchrony in larger groups increased prosocial behaviour and positive affect, but group size did not moderate the relationship between synchrony and perceived social bonding and social cognition. This pattern suggests that distinct process mechanisms (neurocognitive versus affective) might underpin synchrony's effects on dimensions of response as a function of group size.

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

Introduction

Synchronous movements and vocalisation involve the matching of actions in time with others (Hove & Risen, 2009). From dancing to singing to marching, synchrony is a commonplace feature of social life, and evidence for synchrony appears deep in the human record (Reddish et al., 2013). The conservation and prevalence of synchronous action suggests tacit evolutionary benefits (Hagen & Bryant, 2003; Haidt et al., 2008; Henrich, 2015). Specifically, it has been theorised that synchronous activities increase social cohesion amongst group members, enhancing cooperative behaviour (Launay et al., 2016; McNeill, 1995; Turner, 1969).

Quantitative evidence for synchrony's prosocial effects was reported by Wiltermuth and Heath (2009). In one experimental study participants walked around a campus together, and in another study they sang and moved cups. The investigators varied levels of synchrony in both studies, and found that synchrony increased donations in a subsequent coordination game involving trust, and a public goods game requiring individual sacrifice for group benefit. Wiltermuth and Heath's (2009) finding that synchrony increases cooperation in behavioural economic games has also received substantial support in subsequent studies (Launay et al., 2013; Reddish et al., 2013). Notably, behavioural cooperation has been observed both within behaviourally synchronous groups (Sullivan et al., 2015), as well as towards outsiders (Reddish et al., 2014). Other studies have linked synchrony to a wide range of social-affective phenomena beyond prosocial behaviour including increased affiliation and liking towards group members (Hove & Risen, 2009; Tarr, Launay, Cohen, & Dunbar, 2015; Tarr, Launay, & Dunbar, 2016), greater levels of subjective rapport (Miles, Griffiths, Richardson, & Macrae, 2010a; Miles, Nind, & Macrae, 2009), and feelings of social connectedness amongst group members (Lumsden et al., 2014). Synchrony has also been shown to increase positive affect (Tschacher et al., 2014), and to improve memory recall of words (Macrae et al., 2008).

Though synchrony's effects on positive social response have been widely observed, enthusiasm for synchrony-induced prosociality is mitigated by some failed replications (i.e., Dam, 2012; Schachner & Garvin, 2010). For example, Schachner and Garvin (2010) conducted a direct replication of Wiltermuth and Heath's (2009) third study and found that synchrony did not increase cooperation, nor perceived social bonding (i.e., trust, similarity, and feelings of being in the same team). Moreover, larger

effects are more likely to be replicated: the relative size of synchrony effects across a larger number of studies needs to be evaluated (see Open Science Collaboration, 2015). Finally, because the experimental studies have assessed social response using behavioural outcomes (e.g., cooperation, helping behaviour, economic games), subjective self-report measures (e.g., social cohesion, trust, interconnectedness, liking, similarity, entitativity, and positive affect), and social cognition measures (e.g., attention to others, memory, etc.), it is theoretically interesting to disentangle potentially different effects along these different dimensions of social response. Table A.1 in Appendix A presents all the outcomes measures used in all the studies included in this meta-analysis.

Here we conduct a meta-analysis evaluating the relative strength of synchrony effects on both direct prosocial behaviours and subjective ratings of social bonding, and use this evidence to explore proposed psychological mechanisms for synchrony-induced social response. Due to insufficient direct replications available, we conducted a meta-analysis of conceptual replications. We investigated the strength of synchrony on the dimensions of response that have been most thoroughly investigated in the literature: (1) prosocial behaviour, (2) perceived social bonding, (3) social cognition, and (4) positive affect.

The quality of any meta-analysis such as ours depends on the choice of relevant comparison conditions. Notably, humans are a hyper-social species and most social action requires some degree of coordinated movement, though not necessarily an exact matching of behaviour in time. Consider an assembly line where labour is divided in a sequential order for the step-wise creation of a product. Similarly, human communication is socially coordinated, but is typically sequential rather than synchronous. What is the effect of synchrony compared to social coordination more generally? We address this key question for synchrony research by comparing exact temporal matching of behaviour with the effects of socially coordinated but not temporally matched behaviour on social/behavioural/cognitive/affective responses.

Exploring Possible Process Mechanisms

Three mechanisms have been proposed for how synchrony affects people. First, researchers have theorised that as people move in synchrony with each other, the boundaries between the self and other become blurred (Hove, 2008). It is hypothesised that such blurring evokes a sense of oneness with the group as a whole (Swann, Jetten,

Gómez, Whitehouse, & Bastian, 2012). At a neurocognitive level, it had been conjectured that the simultaneous activation of one's own muscles and the observation of others behaving in an identical way leads to a blurring of the self and other in the mind of the individual (Hurley, 2008; Rizzolatti & Craighero, 2004). Compared to general socially coordinated behaviour such as asynchronous or sequential actions, the model predicts that synchronous actions will suppress self/other boundaries more due to the time- and phase-locked nature of exact synchrony (Hove, 2008). However, the blurring-of-self model does not entail that synchrony increases explicit social cognition or social affect.

Second, it had been theorised that social bonding arises from group-centred social cognition. For example, Macrae et al. (2008) argued that a social allocation of attention during synchronous action affects positive social outcomes through greater attention to and processing of the actions of group members, which then allows group members to translate subjective feelings of social cohesion into joint action (see also Miles et al., 2010b; Valdesolo et al., 2010). A similar logic was investigated in Reddish et al. (2013), in which social and individual goals were independently manipulated under varying degrees of coordination. In this study, path analysis supported the theorised model in which synchronous actions when combined with shared goals enhance cooperative expectations, and through this path, enhance cooperative behaviours. The notion is that synchrony towards a common goal rehearses cooperation, which enables people to predict each other's cooperation in the future. The authors conjectured that the importance of shared goals may explain the cultural selection and conservation of traditional and religious rituals, in which sacred beliefs and values were prominent. A common logical thread unifying process models such as Macrae et al. and Reddish et al.'s is the proposition that synchronous movements and vocalisations first affect social cognition, which in turn drives cooperative action. Notably, such models do not imply that synchrony increases subjective affect. It is possible that people predict and respond cooperatively without special emotional adjustments.

Third, it had been theorised that synchrony affects people's affective sensibilities. For example, Emile Durkheim (1912/1995) coined the term "collective effervescence" to describe the emotional effects of rituals. Durkheim (1912/1995) stated, "Once the individuals are gathered together, a sort of electricity is generated from their closeness and quickly launches them to an extraordinary height of exaltation" (p. 217). Building on Durkheim's theories, Haidt et al. (2008) offered a "Hive

Hypothesis" for ritual action, which claims that a person's well-being is enhanced when immersed with social groups. This position builds on the work of McNeill (1995) and Ehrenreich (2006) who postulated that synchronous activities performed in rituals, such as rhythmic drumming and dancing, foster social cohesion and a sense of oneness with the social group by modulating basic affective states and emotions. Though an increase in positive affect has been found in a non-verbal synchrony study (Tschacher et al., 2014), most laboratory experiments have failed to support consistent influences on social emotions (e.g., Reddish et al., 2013; Schachner & Garvin, 2010; Wiltermuth & Heath, 2009). Despite a lack of uniformity in the evidence linking synchrony to cooperation by an affective channel, this mechanism remains a strong theoretical contender for explaining the endurance of ritualised synchrony. Notably, there are marked differences between naturally occurring ritual synchrony and laboratory manipulations, which typically are deliberately constructed to eliminate affective "confounds." On the other hand, the social-affective dimensions of rituals are vividly portrayed throughout ethnographic records, and in systematic studies of naturally occurring religious rituals (Bulbulia et al., 2013; Fischer et al., 2014; Xygalatas et al., 2013). Thus, evidence for even a subtle effect of synchrony on positive affect would be consistent with widely postulated affective mechanisms at work in human rituals.

Importantly, the three process mechanisms we investigate in this meta-analysis are not exclusive. It could be that the three postulated mechanisms variously operate in conjunction, depending on the situation or culture. Moreover, other process mechanisms besides the three we investigate have been proposed to explain synchrony effects on people. For example, neurobiological theories hypothesise that modulation of the endogenous opioid system affects social response, highlighting the role of endorphins, dopamine, serotonin, and oxytocin (Launay et al., 2016); in particular in relation to modulations of pain perception (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Sullivan et al., 2015; Tarr et al., 2015). These theories too are consistent with the others we have described; they merely focus on a different level of explanation – the brain. Our present meta-analysis focuses on social, behavioural, affective, and cognitive dimensions. However, neurobiological mechanisms including the endogenous opioid system and neurotransmitter functioning are important horizons of further meta-analyses, once more primary studies are available.

Might Size Matter?

We note that the current literature has paid relatively limited attention to the effect of group size on behavioural, social, cognitive, and affective responses. Notably, early synchrony research focused on dyadic interactions, where attention among pairs was directed to a single interactive partner. However synchronous activities in natural human ecologies typically occur in groups (i.e., dancing, singing, and marching). It is plausible that group size moderates synchrony's effects on various dimensions of response (Launay et al., 2016; Tarr, Launay, & Dunbar, 2014; Tarr et al., 2015). On one hand, the number of interactive partners imposes attentional burdens, and social prediction becomes more difficult (Tarr et al., 2014). On the other hand, the ethnographic literatures that imply effervescent mechanisms are based on observations of larger group settings. Thus, synchronous actions in large groups may tend to recruit emotional resources to express positive group-level social behaviours. Indeed, being in a large mass of people moving together in synchrony may be emotionally arousing and increase positive affect regardless of whether synchrony is tightly coupled (Tarr et al., 2016; see also Durkheim, 1912/1995, and Le Bon, 1895/2009 for alternative views).

Put simply, group size offers a clear avenue for distinguishing the relative importance of proposed mechanisms for synchrony's effects on social response. Attentional mechanisms are likely to be restricted to small groups. Effervescence is likely to be evident in large groups more so than in small groups. Evidence that "size matters" to synchrony's effects would reveal how proposed synchrony mechanisms might be *both* compatible *and* exclusive. Much as an automobile's gearbox affords compatible and exclusive mechanisms for powering the vehicle, so too, synchrony may operate very differently depending on the size, structure, and context of a social group. This horizon of possibility has yet to be experimentally investigated in the synchrony literature, however naturally occurring variability in group size across the experimental literature affords some initial inference.

Method

Literature Search and Selection of Studies

We conducted an electronic literature search in PsycINFO on May 1, 2016. An initial search using the keyword "synchrony" yielded a list of 3,478 potential studies. We refined the search by using the keywords "*behavioural synchrony, vocal synchrony,*

interpersonal synchrony, interactional synchrony, OR group synchrony", yielding 442 sources in total. We also searched the reference sections of all articles identified in this initial search. In addition to the electronic search, we contacted prominent synchrony researchers via email. Of the 17 researchers contacted, 11 responded with further published and unpublished studies.

In this study, we have defined synchrony as the exact rhythmic matching of actions in time and in phase with another person (e.g., when two individuals lift their right arms at the same time and speed with each other, and then lift their left arms at the same time and speed with each other). The control conditions in this study were separated into two groups – socially coordinated conditions and no action conditions. Socially coordinated conditions included movements/vocalisations that were either asynchronous (e.g., when two individuals lift their right arms at different times or speeds from each other; one lifts the arm faster than the other), or frequency-locked but not phase-locked (e.g., when one individual lifts the right arm, the other drops the right arm). The no action conditions included conditions where participants did not perform any movement/vocalisation, or participants performed the task alone without anyone else moving. We compared exact synchronous actions against these two conditions for two reasons. First, exact synchronous actions and social coordination (i.e., asynchrony or sequential actions) may involve different psychological mechanisms. For example, the self-other blurring mechanism proposes that exact synchronous actions compared to other kinds of coordinated action may produce stronger psychological effects because one's own actions occur simultaneously with the actions of others. By contrast, Durkheim's theory of collective effervescence implies that any coordinated group movement regardless of exact temporal synchronicity may produce psychological effects. Uncertainty about the role of exact temporal matching of actions prompted us to include this comparison. Second, levels of attention may affect social response and cognition, and previous research has found that asynchrony may reduce attention (Reddish et al., 2013). We therefore assessed synchrony, asynchrony, and a baseline condition of no action/movement to separate the potentially distinctive effects of these three conditions on the four dimensions of social response we investigated in this meta-analysis.

Our meta-analysis used the following inclusion criteria: (a) the study had to be conducted with humans (versus animals), (b) participants were adolescents older than 14 years of age or adults, (c) the sample was a non-clinical population and had no

physical or mental health problems, (d) synchrony was manipulated experimentally, and (e) sufficient data were reported in the study to calculate effect sizes. Our final sample consisted of 42 independent samples with 4,327 participants reported in 26 articles and unpublished studies which were conducted or published between 1988 and 2015 (see Table A.1 in Appendix A for a list of the 42 studies and the corresponding dependent variables from each study). Unpublished studies here refer to studies that were not published in a journal article (i.e., theses) and studies where the datasets were not published at the time of the literature search. Figure 3.1 is an adapted version of the preferred reporting items for systematic reviews and meta-analyses (PRISMA; Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2010). The PRISMA is a four-phase flow diagram which depicts the systematic process of achieving the final sample of studies through the different phases.

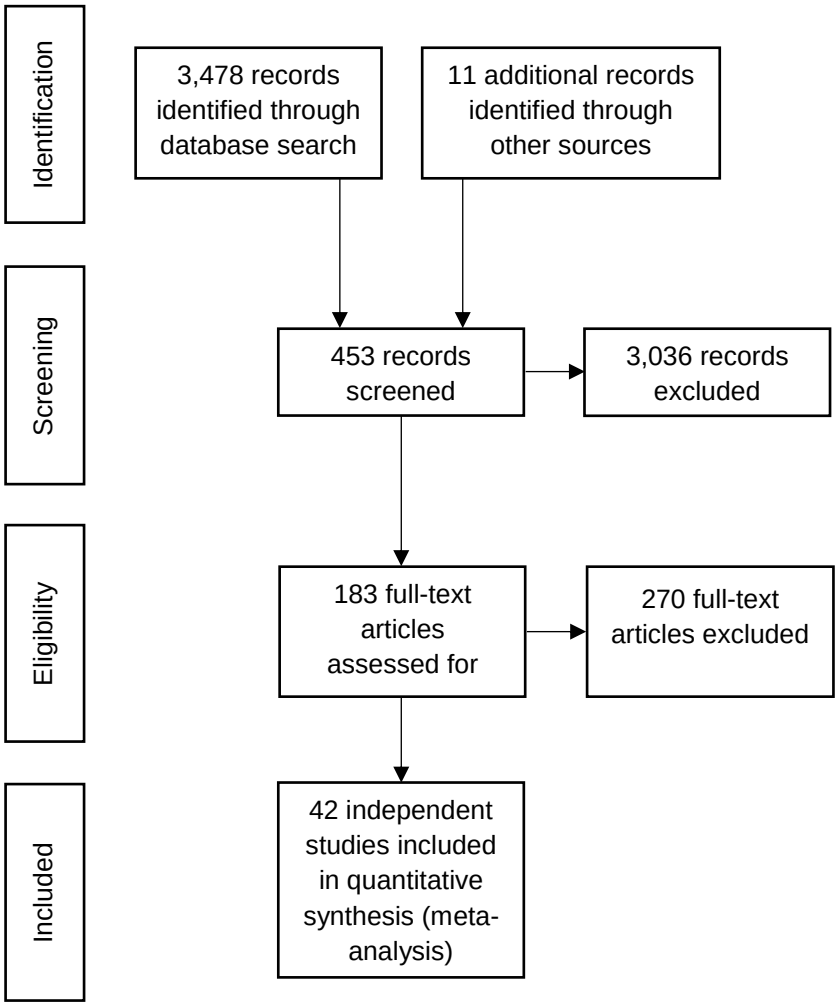


Figure 3.1. Adapted PRISMA flow diagram.

Computation of Effect Size

All effect sizes were calculated as Pearson's correlation coefficient (*r*) due to computational advantages of *r* over alternative effect size measures such as Cohen's *d* or Hedges's *g* (see Rosenthal & DiMatteo, 2001, for a discussion). When available, *r* was directly calculated from the means, standard deviations, and sample sizes for each study. Otherwise, the effect sizes were calculated by converting the *t, F,* or chi-square statistical test values to Pearson's *r*s. The calculations and conversions were obtained using the formulas provided by Lipsey and Wilson (2001). Each Pearson's *r* was standardized using Fisher's *r*-to-*Z* transformation (see Lipsey & Wilson, 2001; Rosenthal & DiMatteo, 2001; Rosnow & Rosenthal, 2003). Each *r*-to-*Z* transformed effect size was then weighted by its inverse variance (Lipsey & Wilson, 2001).

We grouped the different dimensions of response into four categories: behavioural measures of social bonding, perceived social bonding, social cognition, and positive affect. Behavioural measures included economic games such as the public goods game and the stag hunt, as well as helping behaviour as direct behavioural indicators of cooperation and prosociality. Perceived social bonding in the literature used a range of subjective measures including trust, entitativity, interconnectedness, closeness, attraction, similarity, liking, affiliation, rapport, social cohesion, self-construal, feelings of belonging, identification, personal value and voice to the group, prosocial intentions, perceived cooperation, perceived competence of the partner, and perceived physical formidability of another. Social cognition measures typically focused on cognitive processes such as attention, memory, theory of mind, perceptual sensitivity of a task, perceptions of freedom, and other group oriented cognitive tasks (i.e., creativity, conformity). Finally, affective measures were reflected in mood scales, which assess positive affect, as well as ratings of general life satisfaction, happiness, and self-esteem. Table A.2 in Appendix A shows a list of all the dependent variables from each study along with descriptions and sample items when provided.

The studies pooled in our meta-analysis varied in their manipulation of synchrony. Behavioural synchrony included walking, running, moving arms, body, and/or legs, stepping, arm swaying, waving, finger tapping, arm curls, rocking chairs, hand tapping, rowing, drumming, and clapping. Vocal synchrony was manipulated via singing, reading, and chanting. There were not enough studies to separate the relative effectiveness for different types of behavioural and vocal synchrony across the various

dimensions. Thus, we combined all forms of synchronous action to evaluate the overall effect of synchrony.

Data Analysis Procedure

We used a random effects with maximum likelihood model to test the synchrony effects because it had the advantage of assuming that there are latent differences between the studies sampled, in addition to subject-level sampling error (Hunter & Schmidt, 2000; Lipsey & Wilson, 2001). Hence, the random effects model accounted for both subject-level sampling error and sampling of different studies from a larger population of studies. This was a more realistic assumption, in particular for this meta-analysis, due to the various ways synchrony was manipulated in the different studies. Using Lipsey and Wilson's (2001) guidelines for *r*, we identified an effect size of 0.10 to 0.25 as "small," 0.25 to 0.40 as "medium", and above 0.40 as "large". All mean effect sizes were assessed using this arbitrary guideline, which we used to present results. Separate analyses were conducted for the four dimensions of response to investigate synchrony's effect on each dimension. For the test of group size as a moderator, we used a random effects regression (see Lipsey & Wilson, 2001). We used the mean of the group size (ranging from 2 to 24 people) as a continuous moderator variable in our analysis. All analyses were conducted using the *metafor* package (Viechtbauer, 2010) in R Version 3.3.1 software (R Core Team, 2016)[1].

Results

We first examined the overall effects of synchrony by comparing it against all experimental control conditions. Focusing on prosocial behaviours (k = 24, N = 1,223), the weighted random-effect mean effect size (M_{ES}) for behaviour was 0.28 with a standard error (*se*) of 0.03, $p < .001$, 95% CI [0.22, 0.34]. The effect size for behavioural measures varied somewhat between studies, Q = 31.72, df = 23, p = .106. We also used the I^2 statistic as a test for heterogeneity, which provides a percentage of the total variability due to the heterogeneity in the study effect sizes (Higgins, Thompson, Deeks, & Altman, 2003). The I^2 was 16.34%, 95% CI [0.00, 68.97] indicating low variance (Higgins et al., 2003).

[1] The R code for the meta-analysis is available in Part A.3 of Appendix A.

The perception effect size was based on a larger number of samples and participants (k = 53, N = 3,262), but showed a smaller effect size, M_{ES} = 0.17, se = 0.03, p < .001, 95% CI [0.12, 0.23]. The effect size was highly heterogeneous, Q = 112.82, df = 52, p < .001. The I^2 statistic was 54.73%, 95% CI [33.94, 70.67] indicating moderate variance (Higgins et al., 2003).

Focusing on the relative effects of synchrony on social cognition (k = 25, N = 1,599), we observed a statistically significant, but small effect size, M_{ES} = 0.17, se = 0.05, p < .001, 95% CI [0.08, 0.26]. These cognitive effects were heterogeneous, Q = 66.48, df = 24, p < .001, and the I^2 statistic was 66.85%, 95% CI [46.02, 85.83] indicating moderate variance (Higgins et al., 2003).

Finally, a total of 24 independent samples (N = 1,501) were available to examine synchrony's effect on positive affect. The overall effect size observed was small, but statistically significant, M_{ES} = 0.11, se = 0.04, p = .007, 95% CI [0.03, 0.19]. The sample of studies' effects was found to be highly heterogeneous, Q = 48.81, df = 23, p = .001. The I^2 statistic was 54.77%, 95% CI [20.96, 76.32] indicating moderate variance (Higgins et al., 2003). Taken together, these results suggest that synchrony has a positive small to medium effect on behaviour and perceived social bonding, social cognition, and positive affect. Figure 3.2 shows a bar graph of the mean effect sizes for all dimensions of response, and Figure 3.3 shows the forest plots for each of the four dimensions along with prediction intervals.

Publication Bias

A concern in meta-analyses is that the effect size estimations may be biased towards studies with statistically significant results and/or results which were in the expected direction. As such, studies showing non-statistically significant findings or opposing patterns often do not get published and hence, are not reviewed. In order to assess for publication bias, we ran Egger's regression test (Egger, Smith, Schneider, & Minder, 1997) and examined the funnel plots separately for each of the four dimensions.

Egger's regression tests on each dimension of response were not statistically significant (behaviour: z = 1.24, p = .216; perception: z = 0.78, p = .437; cognition: z = -0.32, p = .746; positive affect: z = 0.41, p = .685). The data do not offer evidence of publication bias. We do not rule out publication bias as a matter for future investigations. However, as our data did not support a publication bias for the

dimensions, we ran all other analyses without including publication status (i.e., published or unpublished at the time of the literature search) as a control variable.

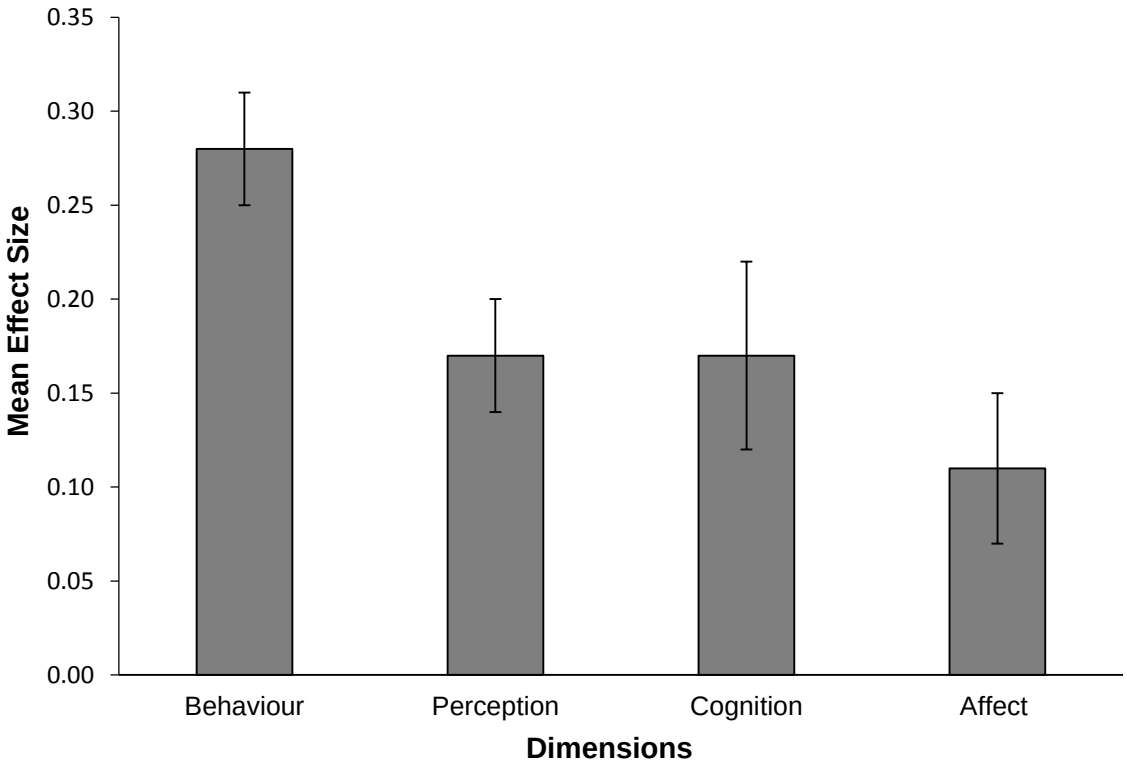
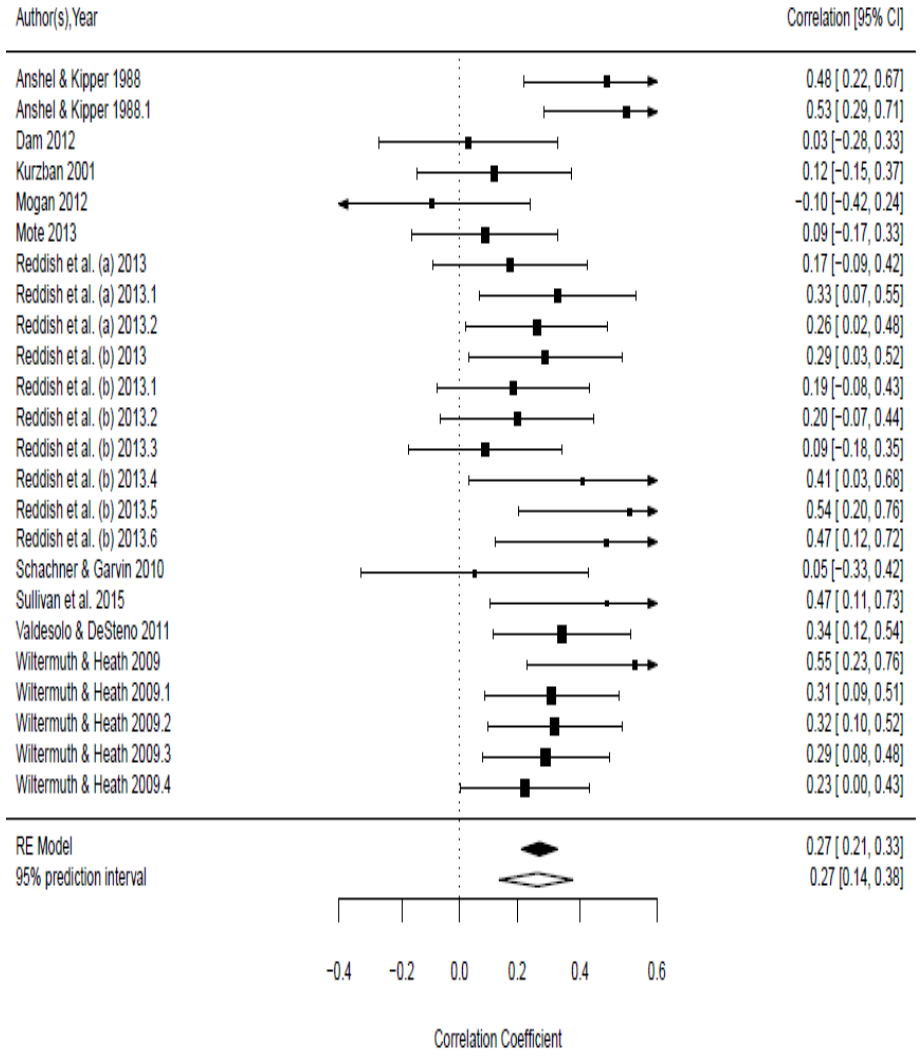
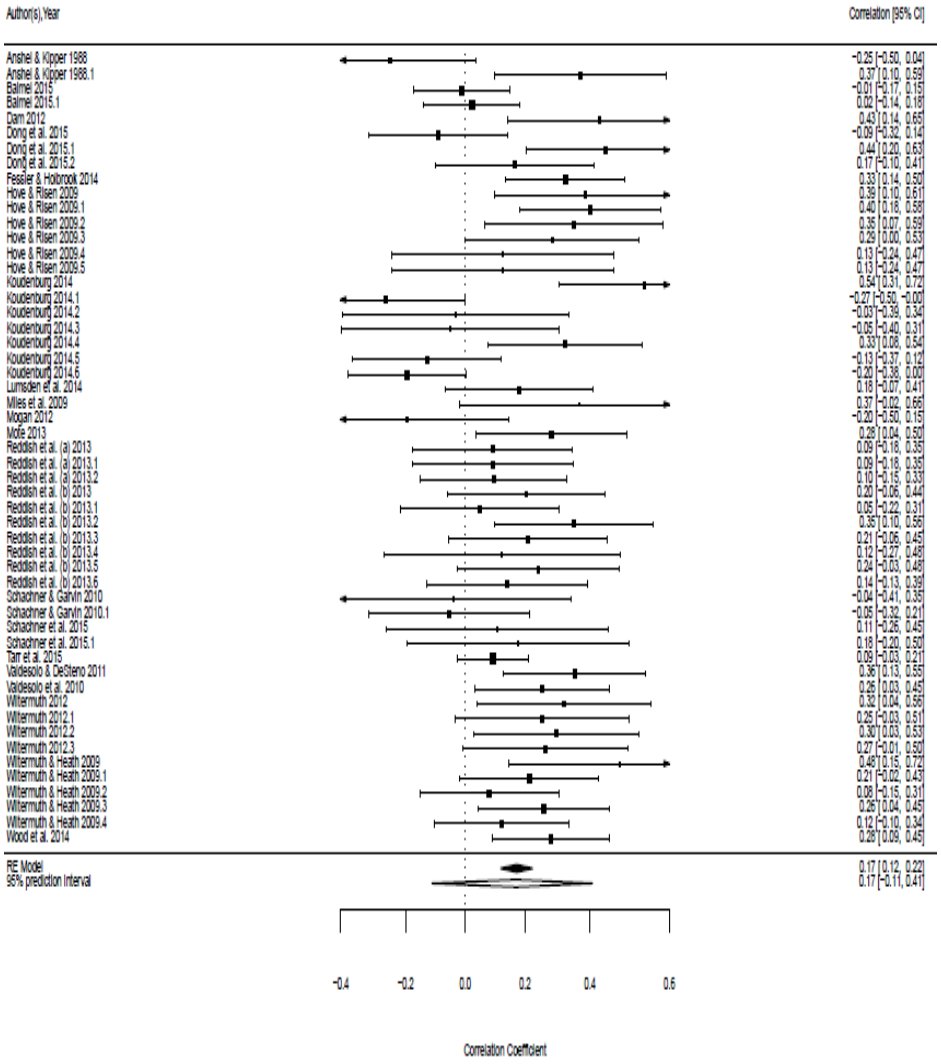


Figure 3.2. Mean effect size of synchrony versus all experimental conditions on four dimensions of response: prosocial behaviour, perceived social bonding, social cognition, and positive affect.

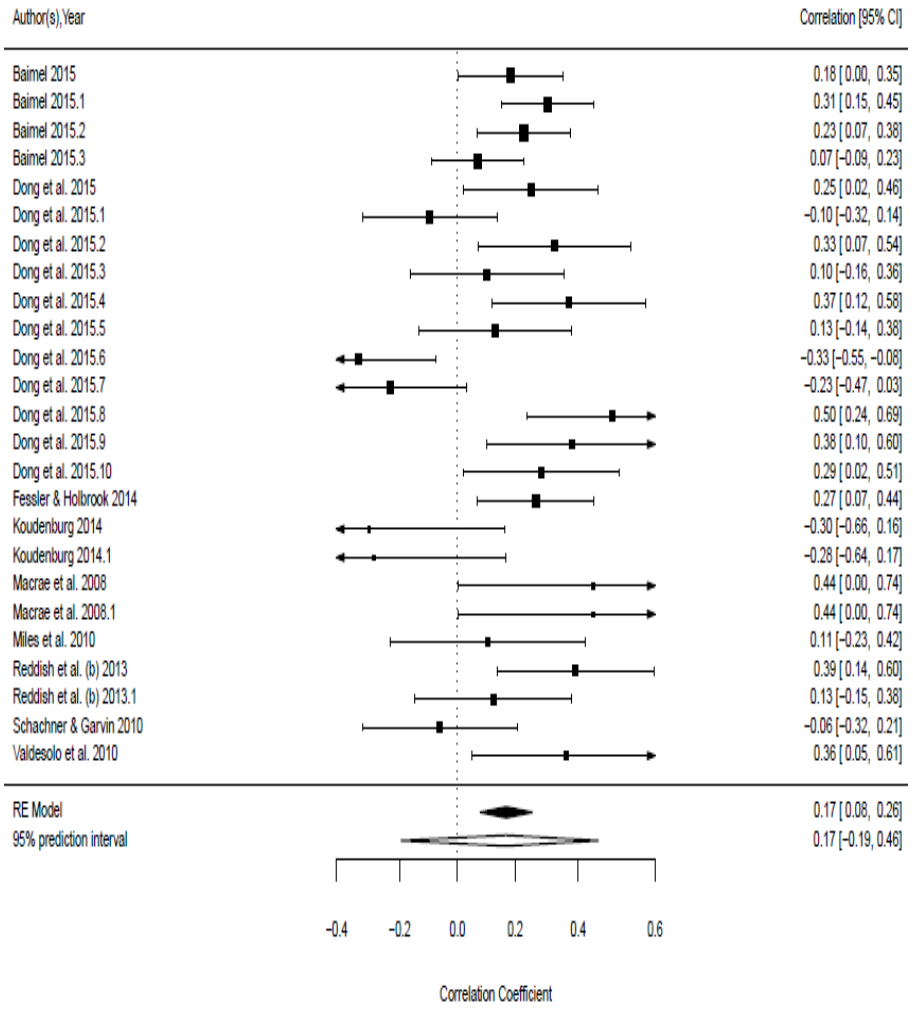
a) Behaviour



(b) Perception



c) Cognition



(d) Affect

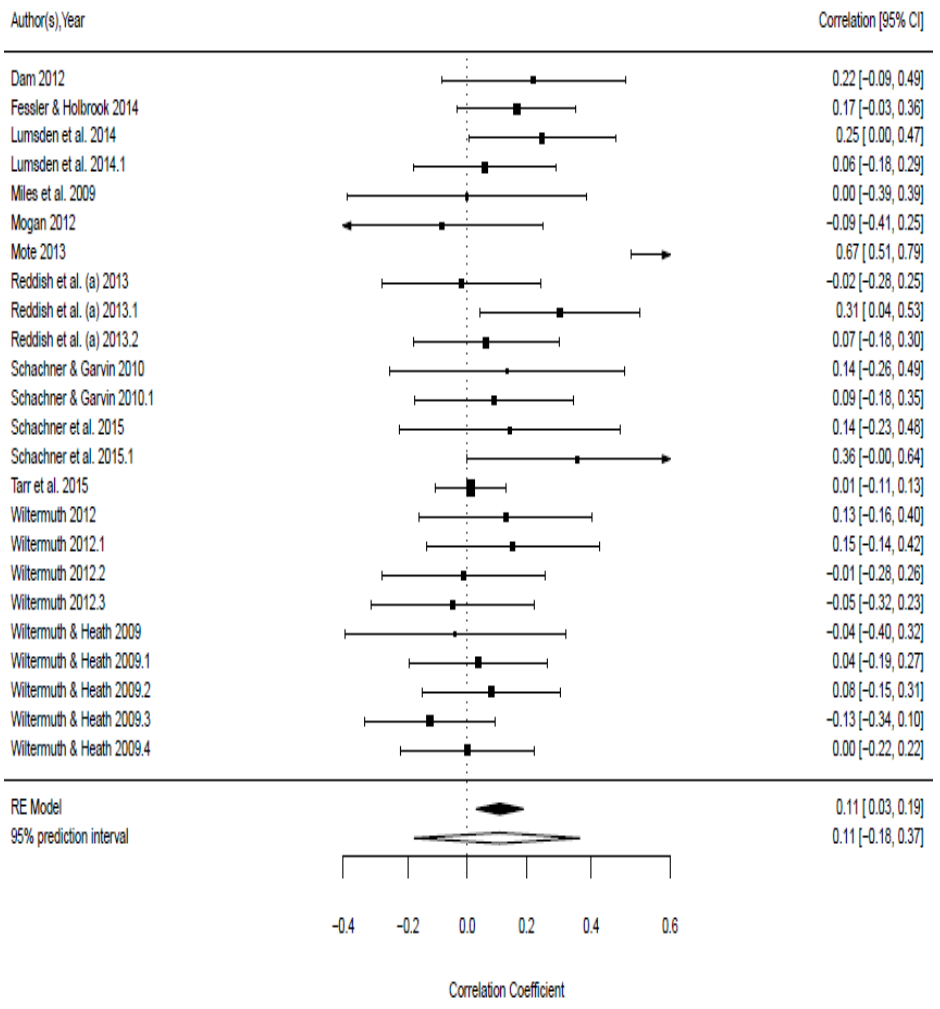


Figure 3.3. Forest plots of the four dimensions:(a) prosocial behaviour, (b) perceived social bonding, (c) social cognition, and (d) positive affect.

To better examine the process mechanisms, we separated the analyses and compared synchrony conditions with control conditions in which there was either (1) no action (movement/vocalisation), or (2) socially coordinated movements.

Synchrony versus No Movement or Vocalisation Controls

We ran a separate analysis of variance (ANOVA) for each dimension of response. The results for synchrony versus no action control conditions showed that synchrony had a statistically significant effect compared with control conditions for behaviour, M_{ES} = 0.27, *se* = 0.05, $p < .001$, k = 10, 95% CI [0.18, 0.37], perception, M_{ES} = 0.18, *se* = 0.05, $p < .001$, k = 14, 95% CI [0.08, 0.29], and positive affect, M_{ES} = 0.20, *se* = 0.07, $p = .008$, k = 7, 95% CI [0.05, 0.34]. We did not detect a statistically significant effect of synchrony on social cognition as compared with control conditions, M_{ES} = 0.48, *se* = 0.30, $p = .117$, k = 1, 95% CI [-0.12, 1.07], however there was only one study (Macrae et al., 2008) for this analysis on social cognition. Table 3.1 shows the mean effect sizes for all the synchrony comparisons. Figure 3.4 shows the results of these synchrony comparisons for all four dimensions of response in a bar graph. These results offer preliminary support for synchrony having a medium effect size on social bonding behaviour and positive emotional responses when compared with no movement/vocalisation. In addition, synchronous actions appear to have a small effect on perceived social bonding.

Synchrony versus Social Coordination Controls

We examined whether synchrony had any added advantage over general social coordination in affecting social bonding behaviours and perceptions, social cognition, and positive affect by contrasting synchrony manipulations with all other socially coordinated manipulations. Contrasts included sequential conditions and various forms of asynchrony. Synchrony versus coordination comparisons revealed statistically significant effects for behaviour, M_{ES} = 0.29, *se* = 0.05, $p < .001$, k = 14, 95% CI [0.20, 0.38], perceptions, M_{ES} = 0.17, *se* = 0.03, $p < .001$, k = 39, 95% CI [0.11, 0.24], and social cognition, M_{ES} = 0.16, *se* = 0.05, $p < .001$, k = 24, 95% CI [0.07, 0.26], indicating support for synchrony increasing prosocial behaviours, perceived social bonding, and social cognition measures over and above non-synchronous social coordination. However, we did not observe a statistically significant effect of synchrony on positive affect over and above social coordination, M_{ES} = 0.08, *se* = 0.05, $p = .120$, k = 17, 95%

CI [-0.02, 0.17]. We did not detect a difference in how synchronous and generally coordinated movements/vocalisations increased positive affect. Figure 3.4 shows the results of these analyses in a bar graph.

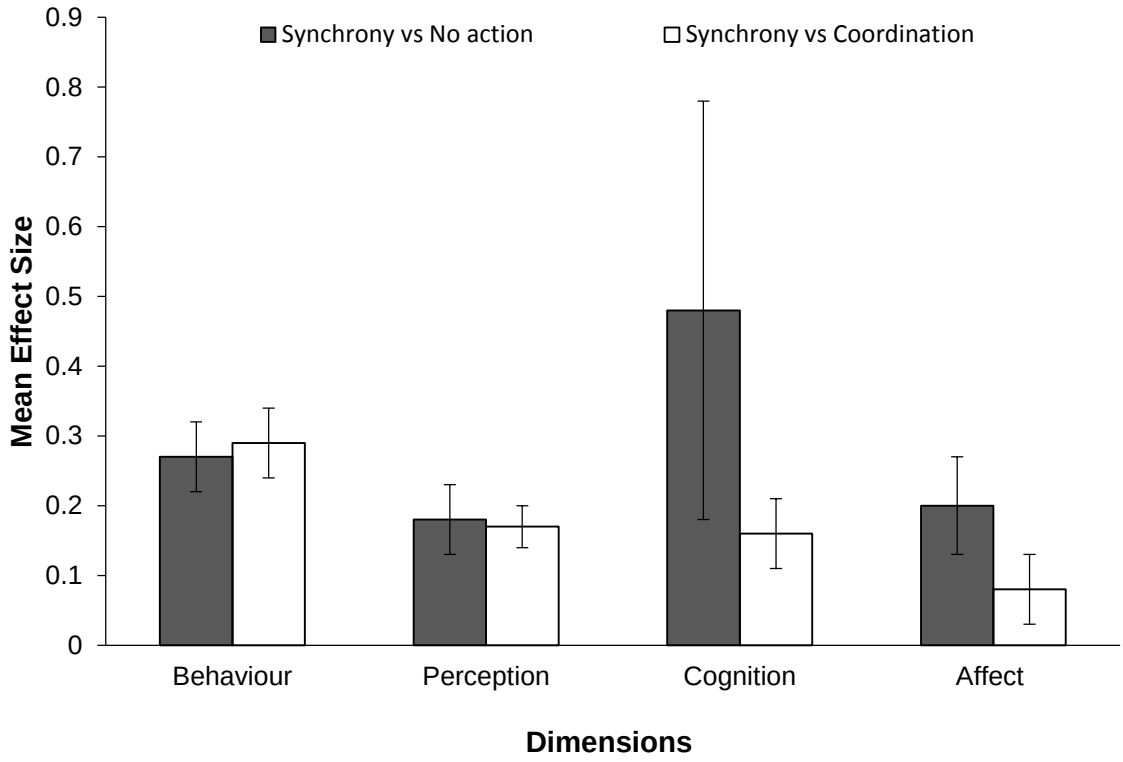


Figure 3.4. Mean effect size of synchrony versus no movement/vocalisation, and synchrony versus coordination on four dimensions of response: prosocial behaviour, perceived social bonding, social cognition, and positive affect.

Table 3.1

Mean Effect Size for Synchrony Comparisons on Four Dimensions of Response

Outcome	Comparison	*ES*	se_{ES}	*K*	*N*	-95% CI	+95% CI
Behaviour							
	Synchrony vs. No action	0.27***	0.05	10	592	0.18	0.37
	Synchrony vs. Coordination	0.29***	0.05	14	631	0.20	0.38
Perception							
	Synchrony vs. No action	0.18***	0.05	14	795	0.08	0.29
	Synchrony vs. Coordination	0.17***	0.03	39	2467	0.11	0.24
Cognition							
	Synchrony vs. No action	0.48	0.30	1	20	-0.12	1.07
	Synchrony vs. Coordination	0.16***	0.05	24	1579	0.07	0.26
Affect							
	Synchrony vs. No action	0.20**	0.07	7	411	0.05	0.34
	Synchrony vs. Coordination	0.08	0.05	17	1090	-0.02	0.17

* $p < .05$ ** $p < .01$ *** $p < .001$

Group Size

We ran a meta-analytic regression model with study effects modelled as random, which was estimated by iterative maximum likelihood. In this model, the mean group size was a continuous predictor and we compared effects of synchrony manipulations against all types of control conditions. The results revealed that group size was a significant positive predictor for social bonding behaviour (B = 0.01, se = 0.01, p = .041, k = 24, 95% CI [0.00, 0.02]), and positive affect (B = 0.09, se = 0.03, p < .001, k = 24, 95% CI [0.04, 0.14]). Prosocial behaviour and positive affect increased with group size.

Group size was not a statistically significant predictor of perceived social bonding (B = -0.00, se = 0.01, p = .470, k = 53, 95% CI [-0.02, 0.01]), or social cognition (B = -0.01, se = 0.02, p = .568, k = 25, 95% CI [-0.05, 0.03]). Nevertheless, the overall trend of the results suggested a negative relationship with both perceived social bonding and social cognition where the effects of synchrony decreased with group size. Table 3.2 presents synchrony's effects by mean group size.

Table 3.2

Synchrony's Effects on Four Dimensions of Response by Mean Group Size

Outcome		*B*	se_B	*k*	*N*	-95% CI	+95% CI	R^2
Behaviour				24	1223			0.98
	Constant	0.22***	0.04			0.14	0.30	
	Mean group size	0.01*	0.01			0.00	0.02	
Perception				53	3262			0.00
	Constant	0.19***	0.04			0.12	0.27	
	Mean group size	-0.00	0.01			-0.02	0.01	
Cognition				25	1599			0.00
	Constant	0.23*	0.11			0.01	0.44	
	Mean group size	-0.01	0.02			-0.05	0.03	
Affect				24	1501			0.63
	Constant	-0.17	0.09			-0.34	0.00	
	Mean group size	0.09***	0.03			0.04	0.14	

* $p < .05$ ** $p < .01$ *** $p < .001$

Discussion

There were two aims of this meta-analysis. First, we systematically tested the relative strength of synchrony's effects on four core dimensions of response: (1) prosocial behaviours, (2) perceived social bonding, (3) social cognition, and (4) positive affect. Second, we investigated whether group size moderated the relationship between synchrony and the four dimensions, and used the results to evaluate constraints on proposed mechanisms for synchrony's effect on social responses.

Our results indicate that when compared to non-synchronous conditions, synchronous movements and synchronous vocalisations (1) increase prosocial behaviours, (2) enhance perceived social bonding, (3) improve social cognition, and (4) increase positive affect. Across the four dimensions of response, we found that synchrony had a slightly larger effect on prosocial behaviours of 0.28 (medium-sized effect), compared to the small-to-medium-sized effect on perceived social bonding and social cognition (both 0.17), and a small effect on positive affect (0.11). However, the differences in effect sizes between the different dimensions were relatively small, with considerable overlap in the confidence intervals.

Interestingly, we find clear support that synchrony as exact behavioural matching increases social bonding behaviours, perceptions, and social cognition over and above general socially coordinated behaviour. This result suggests that neurocognitive processes may be important in synchrony's influence on behaviour, perception, and cognition, possibly through self-other blurring and increased attention. However, we do not find evidence from the existing literature that a tight coupling of actions results in greater positive affect compared with asynchronous movements or sequential movements. We infer that coordination of movement increases positive affect, but that such responses are unlikely to rely on exact behavioural matching. Based on this logic, it is credible that affective responses arise from mechanisms that differ from those responsible for driving social bonding behaviour, perception, and cognition.

In line with the hypothesis that distinct process mechanisms for synchrony operate in different settings, we observe that group size moderates the relationship between synchrony and both prosocial behaviour and positive affect. Synchrony's effect on prosocial behaviours and positive affect increases as group size increases. By contrast, we do not find evidence that group size moderates the relationship between synchrony and perceived social bonding or social cognition. Notably, Tarr and

colleagues (2014; 2016) proposed that group size could impact the effectiveness of self-other blurring, in that self-other blurring is less likely to occur with a large group of people. Our finding that group size acts as a moderator for synchrony's effects on dimensions of social response offers tentative support for Tarr et al.'s hypothesis. Our finding is also consistent with attention models, which imply that attention is diminished and partners' specific evaluations will be compromised as groups grow larger, which inhibits the prediction of each other's future cooperation and actual cooperative behaviour (Reddish et al., 2013). In agreement with Tarr and colleagues and the attention models, we therefore propose a "size matters" synchrony model in which distinct mechanisms underpin synchrony's effects on social bonding depending on the number of interactive partners. According to Tarr et al. (2014), in small groups, greater attention to the movements of group members and greater partner identification lead to a greater self-other blurring. We speculate that people may be mirroring each other's synchronous actions which facilitate the self-other blurring. Mirroring is a neural mechanism by which people learn through observation (Frith & Frith, 2012), and might be particularly powerful during dyadic and small group interactions as the small number of interaction partners allows a conscious monitoring of the partner(s).

Interestingly, our meta-analysis reveals that at large scales, affective mechanisms are salient. Therefore, we propose that synchrony in large groups drives prosocial effects through affective mechanisms, or what Durkheim termed collective effervescence. Moreover, such pathways are not bound by the conscious tight coupling of matching behaviours. Speculating, it may be that affective responses facilitate cooperation relatively automatically without relying on the partners' specific expectations. Such a mechanism would be consistent with the theoretical observation that at large social scales, coordination is improved by operating independently of social prediction (Bulbulia, 2012). Shifting focus to the neurobiological level, as people still report increases in perceived social bonding in large groups, a possible explanation could be due to the endogenous opioid system (Launay et al., 2016; Tarr et al., 2015). These explanations warrant further investigation and replication in high-powered studies, as well as attention to interactions of this system with others related to reward and social bonding. We should not expect a simple one-size-fits-all explanation.

Additionally, our findings point to the need for synchrony research that distinguishes between how modalities of synchronised behaviour (e.g., vocalisation, rhythmic movement of the whole body [marching, dancing], synchronisation of isolated

body parts [tapping]) affect social and affective responses. Naturally occurring ritualistic behaviours occur across the spectrum of behavioural modality. However, whether distinct modalities of synchrony affect people differently remains unclear. The diverse set of studies included in the current meta-analysis do not allow us to draw any more definite conclusions.

Also needed are future investigations that clarify how synchrony recruits and/or loads attentional and affective systems to modulate social response. At present, the relationship between blurring of self and other, attention, and social prediction cannot be clearly disentangled. Because our meta-analysis does not clarify the pathways by which self-other blurring, attention, social cognition, and affect inter-relate, we recommend that further studies identify and test possible vectors, while adjusting for the size of the synchronous group. We expect progress in the study of coordinated group action from investigations that examine how affective pathways are activated, and are linked with social perception and action.

Overall, the findings of this meta-analysis reveal that synchrony increases all commonly studied dependent variables, but the specific effects differ in strength; synchrony influences cooperative behaviour more than it influences perceived social bonding, social cognition, and affect. Our finding that (group) "size matters" implies that distinct process mechanisms may underpin synchrony's effects. Synchrony's influence on social behaviour, perception, and social cognition may arise by recruiting attentional processes in small group settings, and affective processes in large group settings. Importantly, the effects of coordinated action on positive affect do not appear to rely on precise behavioural matching, indicating the operation of other affective group processes as group size scales up.

Chapter 4

Study 2

The Effects of Behavioural Synchrony on Creative Thinking

Abstract

Synchronised actions have been shown to have positive social and affective effects, yet little is known about their effects on our cognitive processes such as creative thinking (i.e., divergent and convergent thinking). We aimed to examine the direct link between synchrony and creative thinking using an established experimental paradigm. A secondary aim was to replicate and extend the amplified positive effects of shared intentionality on social and affective responses. Participants (N = 138) were randomly assigned to move in synchrony, asynchrony, or passively observe others moving. To induce shared intentionality, they were assigned to either a group or individual goal condition. Our results revealed that synchrony's impairment on convergent thinking is dependent on shared intentionality, but we did not find statistically significant differences for divergent thinking. Additionally, we replicated synchrony's effect on cohesion and positive affect.

A revised version of this chapter was submitted to Frontiers in Psychology.
Mogan, R., Bulbulia, J., & Fischer, R. (manuscript submitted). Behavioural synchrony and shared intentionality affect components of creativity differently. *Frontiers in Psychology.*

Introduction

Synchrony is the matching of actions in time with others (Hove & Risen, 2009). From dancing and singing, to marching, synchronised actions are prevalent in human activities, possibly because of tacit evolutionary benefits (Hagen & Bryant, 2003; Henrich, 2015), such as increasing prosocial behaviours and social bonding (McNeill, 1995; Turner, 1969). Most studies examining synchronised actions have focused on prosocial behaviours, or social and affective responses (see Mogan, Fischer, & Bulbulia, 2017). Less is known about the relationship between synchrony and cognitive processes. The current study aims to investigate any synchrony effects on creativity as a key component of cognitive performance.

Guilford (1967) introduced the distinction between two components of creative thinking – divergent thinking (generating multiple alternative and typically original solutions to a problem), and convergent thinking (forming associations to synthesise ideas and generate a single, best solution to a problem, see Cropley, 2006). Synchrony may affect these two components of creative thinking differently. Durkheim (1912/1995) was the first to suggest that matching movements during rituals may lead to conformity of thought. Experimental evidence suggests that synchronised actions may lead to a blurring of self-other boundaries (Hove, 2008), because matching someone's actions and at the same time observing those matching actions blurs the perception of self and perception of other in the mind (Hurley, 2008). This increases perceptions of similarity between people (Liebenberg, 2017), which results in a mental state which could stifle uniqueness and individuality, inhibiting divergent thinking.

This reasoning is in line with real-world observations. Janis (1982) observed that highly cohesive groups tend to engage in 'groupthink', a phenomenon where group members conform to the normative ideas of other group members. This lack of divergent thinking (Taylor, Berry, & Block, 1958) leads to impaired group performance (Janis, 1982; Larey & Paulus, 1999). Since synchronous actions have been shown to increase perceptions of social bonding among group members, including social cohesion (Mogan et al., 2017), synchronous actions could potentially lead to more convergent thinking and less divergent thinking. We are the first to experimentally test these predictions.

A secondary aim of this study is to replicate and extend previous work on shared intentionality as a possible underlying mechanism explaining synchrony's positive

effect on social and affective responses. Reddish et al., (2013) demonstrated that synchrony effects were only evident when participants shared a goal, which supports Tomasello et al.'s (2005) suggestion that shared intentionality, or shared purpose, creates coordinated mental states. This shared intentionality may be the crucial factor leading to more conformity of thought (Hu, Hu, Li, Pan, & Cheng, 2017). Therefore, we aim to replicate Reddish et al.'s (2013) findings using the same experimental protocol (but without measuring cooperative behaviour), and predict greater conformity of thought. Extending Reddish et al. (2013), we then in turn predict greater convergent thinking and less divergent thinking when shared intentionality is manipulated. Finally, we also included a passive observer condition, to examine whether observing synchronicity is sufficient for eliciting social cohesion (Lakens, 2010). Mogan et al. (2017) found that perceptions and behaviour may yield somewhat different results depending on the type of movement (i.e., synchrony, asynchrony, or no movement/move alone). The inclusion of this condition will therefore allow us to evaluate whether observing others moving in any form is sufficient or whether active synchronous movement is necessary to yield social cohesion.

Method

Participants

138 first year psychology students at a large New Zealand university (88 females; mean age = 19 years, *SD* = 3.33 years) participated in groups of three in exchange for course credits. Although Mogan et al.'s (2017) meta-analysis revealed that group size was positively correlated to synchrony's effect on positive affect, the study also showed that group size may be negatively correlated to synchrony's effect on cognitive outcomes. Since the main aim of this study is to investigate synchrony's effect on creative thinking which is a cognitive outcome, we chose to have participants perform movements in groups of three following from Reddish et al.'s (2013) research paradigm for experiment 3. The study was approved by the university's Human Ethics Committee (ID: RM019282), and all participants provided written consent. A power analysis conducted in G*Power Version 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) suggested that a total sample size of at least 100 participants is needed to achieve 95% power to detect a similar effect size as that of Reddish et al.'s (2013) experiment 3

effect of synchrony on cohesion ($F(2, 76) = 6.15$, $p < .010$, $\eta_p^2 = 0.14$). The number of participants in each cell ranged from 21 to 30 participants.

Design

We used a 3 (Movement: synchrony, asynchrony, passive observation) x 2 (Goal: individual, group) between-subjects factorial design. We used the stepping paradigm by Reddish et al. (2013, experiment 3). Participants were each given a pair of headphones, through which metronome beats were played. They were instructed to march on the spot for six minutes by stepping their foot down on each beat. They were also instructed to lift and drop the same side arm (i.e., lift their left arm up in front of them while lifting their left leg, and drop the left arm back down when they stepped the left leg down; this was repeated with the right arm and leg).

In the individual goal conditions, participants were told to only pay attention to and move according to the metronome beats heard through their headphones, which were played for the duration of the movement task. In the group goal conditions, the metronome beats were played for the first 30 seconds. After that, the sound stopped and participants were instructed to work together to perform the movements according to their assigned movement condition. To increase the salience of the goals, participants were told their performance was video recorded to assess individual performance in the individual goal condition, and group performance in the group goal condition.

Participants in the synchrony condition performed the movements in time with each other at 55 beats per minute (bpm). In the asynchrony condition, each participant performed the movements at different speeds, either at 45 bpm, 55 bpm, or 65 bpm[2]. To further help participants in the asynchrony group goal condition to move out of time with each other, the middle participants (55 bpm) were told to try their best to keep to the rhythm the initially heard. The participants with the slowest speed (45 bpm) were told to slow down the speed of their movements if they found themselves moving in time with another, and participants with the fastest speed (65 bpm) were told to speed up their movements if they found themselves moving in time with another. In the

[2] Prior to starting the study, we conducted a pilot study to test different speeds (45 bpm, 55 bpm, 65 bpm, and 75 bpm) at which participants could comfortably perform the movements for a sustained duration of time. Participants reported that performing the movements at 75 bpm was too fast, but the other speeds were manageable.

passive condition, participants silently watched a video of three confederates performing the movements in synchrony.

Dependent Variables

We measured creative thinking performance immediately after the movement manipulation. The two creative thinking tasks were counterbalanced across individuals. We used the Alternate Uses Task (AUT; Guilford, 1967) to assess divergent thinking. Participants were instructed to list as many uses as they could for two items – a newspaper and a paperclip – and were given two minutes for each item. Following the Consensual Assessment Technique (CAT; Amabile, 1982) to assess participants' responses, two independent coders rated each response on creativity (intra-class correlation [ICC] = 0.78, 95%CI [0.76, 0.80]), and novelty (ICC = 0.71, 95%CI [0.69, 0.74]) on a 7-point Likert scale. We included fluency (the total number of responses from each participant) as a third index.

Convergent thinking was assessed using the Remote Associates Test (RAT; Mednick, 1962). Participants were presented with 10 items. Each item contained a set of three unrelated clue words, and the task was to identify a fourth word which was conceptually related to each of the three clue words. For example, the word "candle" is associated to the clue words of "light", "birthday", and "stick" independently. Participants were given two minutes to complete the RAT.

Cohesion was measured as a composite of four constructs – interconnectedness, entitativity, trust, and perceived similarity (explained 36.57 % of variance, Cronbach's $\alpha = 0.91$). Interconnectedness was assessed with Reddish et al.'s (2013) adapted version of the Inclusion of the Other in the Self scale (IOS; Aron, Aron, & Smollan, 1992) – a pictorial scale with two circles of increasing overlap indicating the interpersonal interconnectedness between the participant and others in the group. Entitativity was assessed with 13 items Reddish (2012) adapted from Denson, Lickel, Curtis, Stenstrom, and Ames (2006), Lakens (2010), and Lickel et al. (2000) (e.g., "*I felt I was on the same team with the other participants*"). We assessed trust using three items from Jarvenpaa, Knoll, and Leidner's (1998) trust measure (e.g., "*The people in my group are very trustworthy*"), and perceived similarity using 13 modified items from McCroskey, McCroskey, and Richmond's (2006) Homophily Scale (e.g., "*People in this group are similar to me*").

We used the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) to assess participants' positive and negative affect. Six positive affect items (*alert*, *inspired*, *determined*, *attentive*, *active*, and the addition of *happy*; $\alpha = 0.79$), and five negative affect items (*upset, hostile, ashamed, nervous, afraid*; $\alpha = 0.73$) were rated on a 7-point Likert scale.

As a manipulation check for the different movement conditions, we asked participants four items taken from Reddish et al.'s (2013) Experiment 2, which assessed their perceptions of synchronicity of the movement task. Examples of these items were: "*How much did you feel you were coordinated with the other participants?*" and "*How much did you feel you were disjointed with the other participants?*" (reverse coded; Cronbach's $\alpha = 0.74$). Finally, to control for familiarity, we asked participants to rate how well they knew each participant before they met for the study.

Results

Manipulation Check and Control

The analyses for the manipulation check and the control variables were conducted with a 3 x 2 Analysis of Variance (ANOVA) with Movement and Goal as the independent variables.

Perceived synchrony. We found a statistically significant main effect of movement on perceived synchrony, $F(2, 96) = 34.95$, $p < .001$, $\eta_p^2 = 0.42$. Participants in the synchrony condition ($M = 5.02$, $se = 0.16$) perceived the movements to be significantly more synchronised compared to the asynchrony ($M = 3.16$, $se = 0.16$, $p < .001$), and passive ($M = 3.88$, $se = 0.24$, $p < .001$) conditions. Participants in the asynchrony condition perceived their movements to be significantly less synchronised compared to the passive condition ($p = .038$). This suggests that the movement manipulation worked.

Prior interactions. We found a statistically significant main effect of movement, $F(2, 132) = 6.43$, $p = .002$, $\eta_p^2 = 0.09$, for how well participants knew each other prior to the study. We therefore controlled for familiarity in all our subsequent analyses with a 3 (Movement) x 2 (Goal) Analysis of Covariance (ANCOVA) with prior interactions as a covariate.

Creative Thinking

Divergent thinking. Each divergent thinking index was analysed separately. The results showed no statistically significant main effect of movement, $F_{max} = 1.37$, $p = .257$, main effect of goal, $F_{max} = 1.04$, $p = .311$, nor interaction of movement and goal, $F_{max} = 1.03$, $p = .359$, on fluency, creativity, and novelty.

Convergent thinking. We did not find a statistically significant main effect of movement, $F(2, 131) = 0.05$, $p = .947$, $\eta_p^2 < 0.01$, or goal, $F(1, 131) = 1.14$, $p = .287$, $\eta_p^2 = 0.01$, on the RAT. However, we found a statistically significant interaction effect of movement and goal on the RAT, $F(2, 131) = 4.31$, $p = .015$, $\eta_p^2 = 0.06$. LSD-corrected pairwise comparisons revealed a marginally significant difference between movement conditions in the group goal condition, $F(2, 131) = 2.58$, $p = .079$, $\eta_p^2 = 0.04$. Figure 4.1 shows that for those who were given a group goal, participants in the synchrony condition ($M = 3.62$, $se = 0.54$) had statistically significantly lower RAT scores compared to the passive condition ($M = 5.01$, $se = 0.46$, $p = .054$). Participants in the asynchrony condition ($M = 3.61$, $se = 0.56$) also had marginally lower scores on the RAT compared to the passive condition ($p = .061$). There were no statistically significant differences between movement conditions in the individual goal condition, $F(2, 131) = 1.74$, $p = .179$, $\eta_p^2 = 0.03$. These results indicate that the goal manipulations affect the RAT in different ways for different types of movements. When given a group goal, participants in the passive condition performed better on the RAT than the synchrony and asynchrony conditions, rejecting the hypothesis that synchronous actions will lead to higher convergent thinking. Refer to Table 4.1 for the adjusted means and standard errors for each condition (see Table B.1 in Appendix B for the correlation table of the dependent variables).

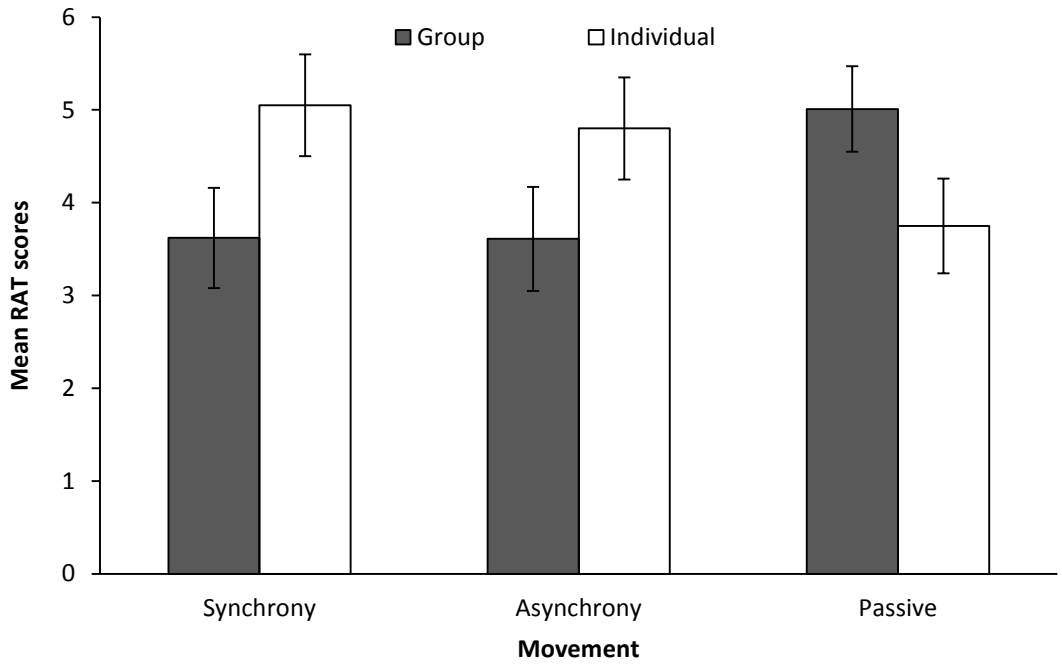


Figure 4.1. Adjusted mean scores on the Remote Associates Test (RAT) based on movement and goal with standard errors.

Table 4.1

Adjusted Means and Standard Errors (in parentheses) of Each Condition

Dependent Variables	Synchrony		Asynchrony		Passive	
	Group	Individual	Group	Individual	Group	Individual
Fluency	14.09 (1.09)	12.41 (1.09)	14.19 (1.12)	12.81 (1.10)	13.76 (0.92)	14.74 (1.02)
Creativity	3.47 (0.14)	3.53 (0.14)	3.20 (0.14)	3.35 (0.14)	3.31 (0.12)	3.39 (0.13)
Novelty	3.77 (0.13)	3.91 (0.13)	3.54 (0.13)	3.72 (0.13)	3.73 (0.11)	3.72 (0.12)
Convergent thinking	3.62 (0.54)	5.05 (0.55)	3.61 (0.56)	4.80 (0.55)	5.01 (0.46)	3.75 (0.51)
Cohesion	3.63 (0.16)	3.82 (0.16)	3.56 (0.16)	3.47 (0.16)	3.35 (0.13)	3.28 (0.15)
Positive affect	3.56 (0.23)	3.58 (0.23)	3.29 (0.24)	3.65 (0.23)	3.04 (0.20)	2.96 (0.22)
Negative affect	1.50 (0.16)	1.52 (0.16)	1.62 (0.17)	1.58 (0.16)	1.82 (0.14)	1.80 (0.15)

Group Cohesion

We found a statistically significant main effect of movement on group cohesion, $F(2, 131) = 3.84$, $p = .024$, $\eta_p^2 = .06$. The main effect of goal, $F(1, 131) = 0.01$, $p = .930$, $\eta_p^2 < 0.01$, and the interaction effect of movement and goal, $F(2, 131) = 0.50$, $p = .607$, $\eta_p^2 = 0.01$, were not statistically significant. LSD-corrected pairwise comparisons showed that cohesion ratings were statistically significantly higher in the synchrony condition ($M = 3.72$, $se = 0.11$) compared to the passive condition ($M = 3.31$, $se = 0.10$, $p = .006$). Contrary to Mogan et al.'s (2017) findings, the synchrony and asynchrony conditions ($M = 3.52$, $se = 0.11$, $p = .194$) did not statistically significantly differ on group cohesion ratings. We also did not replicate the findings by Reddish et al. (2013) on shared intentionality amplifying synchrony's effect. Our results indicated that performing actions together with others is sufficient to increase cohesion among members and shared intentionality did not matter.

Affect

The results revealed a statistically significant main effect of movement on positive affect, $F(2, 131) = 3.88$, $p = .023$, $\eta_p^2 = 0.06$. The synchrony ($M = 3.57$, $se = 0.16$) and asynchrony ($M = 3.47$, $se = 0.17$) conditions did not statistically significantly differ from each other ($p = .674$). However, both the synchrony ($p = .010$) and asynchrony conditions ($p = .042$) had significantly higher positive affect ratings compared to the passive condition ($M = 3.00$, $se = 0.15$). This is in line with the meta-analysis results by Mogan et al. (2017) showing that coordinated actions increase positive affect. The main effect of goal, $F(1, 131) = 0.30$, $p = .586$, $\eta_p^2 < 0.01$, and interaction effect of movement and goal, $F(2, 131) = 0.53$, $p = .593$, $\eta_p^2 = 0.01$, on positive affect were not statistically significant. We did not find a statistically significant main effect of movement, goal, nor an interaction effect of movement and goal interaction on negative affect, $F_{max} = 2.11$, $p = .125$. Replicating Mogan et al.'s (2017) results, the active performance of movements appears to produce an effect on positive affect compared to merely observing other people perform movements.

Discussion

Synchrony's Effect on Creative Thinking

We found an interaction between the different movements and goals for convergent thinking. Synchrony's effect on convergent thinking was dependent on the intention or goal provided. When provided with a group goal (i.e., shared intentionality), performing synchronous and asynchronous actions impaired convergent thinking processes, but not performing any movement at all enhanced convergent thinking processes. However, we did not find statistically significant differences between movement conditions when participants were provided with an individual goal of focusing on their own movements. These results do not support the hypothesis that synchronous actions will lead to more convergent thinking.

A possible explanation could be due to the reduced cognitive capacity during body movements. Dietrich (2006) argued that during exercise, there is a shift in cortical activity to brain regions required to sustain the movements, which results in decreased cognitive capacity in other brain regions not required for movement. This reduction may also last after the physical activity has stopped (Schneider et al., 2013). Participants in the movement conditions could have had a reduction in cognitive capacity which was amplified by the attention they paid during the movement tasks when provided with a group goal of working together to stay in time or out of time with each other. This may have led to lower convergent thinking scores for participants in the synchrony and asynchrony conditions compared to those who passively observed movements.

However based on the cognitive capacity hypothesis, we would also expect to find lower divergent thinking scores for participants in the synchrony and asynchrony conditions due to reduced cognitive capacity. Yet we did not find support for the hypothesis that performing synchronous actions will lead to lower divergent thinking scores, indicating that specific movement types or goals do not affect one's ability to generate multiple ideas. An alternative explanation is that the duration of the movement activity was too short to elicit effects on divergent thinking. In their meta-analysis, Chang et al. (2012) found that physical activity of at least 20 minutes was necessary to observe effects on some cognitive processes. It is likely that divergent thinking is one of the cognitive functions that require a longer duration of movement activity.

Synchrony's Effect on Group Cohesion and Positive Affect

Our results showed that both synchronous and asynchronous actions increased group cohesion and positive affect among participants, in comparison to participants who passively observed synchronous actions. Considering the effects on social cohesion, our study replicates the findings of Baimel et al. (2018), who also found that synchronous and asynchronous movements increased social cohesion when compared to a control condition of no movement. Our results for positive affect replicated Mogan et al.'s (2017) meta-analysis which reported that both synchronous and asynchronous actions increased positive affect when compared to control conditions of no movement such as passive observation. From these results, it can be suggested that it is the active performance of actions which elicits increased positive affect.

Coordinated action as a whole, regardless of synchronicity, appears to be sufficient to elicit positive social and affective effects. In support of Emile Durkheim's (1912/1995) concept of *collective effervescence* and Victor Turner's (1969) *communitas*, when people come together and move together, they form a bond which translates into positive social and affective outcomes for members involved. Based on our results, these positive effects do not translate to passive observers.

Conclusion

Our study appears to be the first to investigate a direct link between synchronous actions and creative thinking processes. This hypothesis is based on sociological analyses which suggest that synchrony's positive effect on cohesion may affect creative thinking by facilitating convergent thinking and impairing divergent thinking. Our attempt to systematically test this hypothesis did not turn up support for it. Speculating, it is perhaps not synchronised movement as such, but rather the underlying shared goals that may induce convergent thinking. Our findings suggest that synchrony and shared intentionality effects on cognitive processes are worth investigating further.

Additionally, synchronous actions often involve some variation of physical effort or intensity from the physical actions required to synchronise (even synchronised vocalisation such as singing in a choir requires physical effort as well, Ainsworth et al., 2011). Physical intensity, which has typically been researched within the exercise and sports literature, has been shown to elicit effects on cognitive, social, and affective outcomes (Chang et al., 2012; Raichlen, Foster, Seillier, Giuffrida, & Gerdeman, 2013). In particular, Colzato, Szapora, Pannekoek, and Hommel (2013) suggested that physical

intensity is an important factor to consider in the examination of creative thinking. They found that effects on divergent thinking differed depending on the level of physical intensity. Since both synchrony and physical intensity have been shown to elicit effects on cognitive, social, and affective outcomes, it is plausible that the effects of synchrony on creative thinking, group cohesion, and positive affect are intertwined with that of physical intensity. Hence, in addition to a further investigation into shared intentionality, the next chapter will also aim to tease apart the effects of synchrony and physical intensity.

Chapter 5

Study 3 and Study 4

Pray Together, Solitary Runner: Separate Effects of Synchrony and Intensity on Cohesion, Mood, and Creativity

Abstract

A recurring element of ritualistic behaviours is synchronised actions, which occur at varying physical intensity levels. Both synchrony and intensity affect social, affective, and cognitive processes. Presently, however, the interaction of synchrony and intensity on these core dimensions remains unclear. We investigated the effect of synchrony and intensity on cohesion, positive affect, and creative thinking. Study 3 used naturally occurring group exercises that varied in synchrony and intensity. Study 4 employed a controlled experimental paradigm manipulating shared intentionality of synchronised actions and intensity. Taking both studies' results together, we replicated previous findings that synchrony paired with shared intentionality increases cohesion, and that intensity increases cohesion among members. Importantly, we observed that synchrony impaired divergent thinking, suggesting that synchronised actions may promote conformity of thought by impairing creativity. By contrast, intensity facilitated creative thinking. The observation that exertion reduces conformity of thought may explain why cultural rituals did not universally evolve as collective exercise, despite exercise's positive influence on mood. By the same token, synchrony's suppression of creativity may contribute to its pervasive spread as a means of stabilising cultural conformity.

Mogan, R., Bulbulia, J., & Fischer, R. (under review). Pray together, solitary runner: Separate effects of synchrony and intensity on cohesion, mood, and creativity. *Religion, Brain & Behavior*.

Introduction

Rituals are prevalent across human life. Though rituals lack explicit means-end functionality, anthropologists speculate that rituals offer tacit benefits, enhancing cooperation, cohesion, and subjective well-being (Durkhiem, 1912/1995). An element of rituals is physical activity, defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, & Christenson, 1985, p. 126). A key physical activity element of many rituals is synchronised action (i.e., the matching of behaviours in time). Synchrony is prominent across a wide variety of human activities such as dancing, singing, and marching. Notably, synchronous actions vary in physical intensity levels (i.e., the amount of energy expended). For instance, the intensity levels differ when a group of people chant (e.g., Gregorian chanting), or when they dance (e.g., whirling dervishes). Synchronous actions in non-religious settings also have varying physical intensity levels, for example in the context of group exercises (walking a marathon is less physically intense than running one). Research has shown that both synchronous actions (Mogan et al., 2017), and physical intensity (Chang et al., 2012; Raichlen et al., 2013) elicit effects on social, affective, and cognitive outcomes. It is likely that both synchrony and intensity interact to influence these outcomes.

Though numerous studies have shown synchrony's positive effects on social and affective outcomes, synchrony's effect on cognitive processes (e.g., creative thinking) remains unclear. Creative thinking has been widely investigated within the field of physical activity (i.e., exercise), but not synchrony. Guilford (1967) distinguished between two main components of creative thinking – divergent thinking and convergent thinking. Though divergent thinking involves generating multiple ideas/solutions to a problem, convergent thinking involves synthesising ideas by forming associations to generate a single, best solution.

In this paper, we examine the effects of both synchrony and intensity, specifically on cohesion, positive affect, and creative thinking. First we summarise previous investigations in synchrony and exercise research which have been conducted largely in isolation of each other.

Effects of Synchrony

Cohesion. Synchronous actions have been argued to enhance social bonding through feelings of oneness and cohesion (Durkheim, 1912/1995). Hove (2008) suggested that mirroring actions blurs the psychological boundaries between the self and the other, thus facilitating cohesion. Evidence for this argument comes from field studies (Fischer, Callander, Reddish, & Bulbulia, 2013) and experimental paradigms (Reddish et al., 2013; Tarr et al., 2016; Wiltermuth & Heath, 2009) showing synchrony's positive effect on social cohesion. Mogan and colleagues (2017) conducted a meta-analysis on 42 independent studies and found that synchronised actions increased perceptions of social bonding and cohesion in experimental settings. Specifically, performing the same actions at the same time with others (i.e., exact synchrony) led to statistically significantly higher prosocial perceptions than non-synchronous coordination with others, or no actions at all.

Positive affect. Anthropologists have reported that people feel increased well-being and positive affect when they come together for an activity, and are immersed in the social group – Durkheim (1912/1995) termed this "collective effervescence". Ethnographic and systematic field studies of ritualistic activities have provided evidence for this (Bulbulia et al., 2013; Fischer et al., 2014; Xygalatas et al., 2013). Specifically, synchrony has been implicated as being a contributing factor to increases in positive affect. Yet, in Mogan et al.'s (2017) meta-analysis, both synchronous and non-synchronous actions were shown to increase positive affect when compared to control conditions of no action. The meta-analysis indicates that regardless of synchronicity, performing actions with others is sufficient to produce states of collective effervescence, and thus increase positive affect (see also Tarr et al., 2016).

Creative thinking. As mentioned, experimentally manipulated synchronous actions have been shown to increase social bonding perceptions, including cohesion and similarity (Mogan et al., 2017). Such feelings of cohesion and similarity may influence creative thinking processes. Emile Durkheim (1912/1995) conjectured that ritualistic activities which have people performing similar movements with each other reflects a prior conformity of thought processes:

> "the [ritual] group has an intellectual and moral conformity…everything is common to all. Movements are stereotyped; everybody performs the same ones

> in the same circumstances; and this conformity of conduct only translates the conformity of thought. Every mind being drawn into the same eddy, the individual type nearly confounds itself with that of the race" (p. 5).

Notably, previous studies have shown that highly cohesive groups are likely to engage in groupthink – a way of thinking that encourages conformity of thought rather than alternative views (Janis, 1982). The conformity of thought inhibits the generation of alternative ideas and solutions, impairing divergent thinking. Ashton-James and Chartrand (2009) found that participants who were not mimicked by an experimenter produced more original ideas compared to participants who were mimicked. They suggested that unconscious synchronised behaviour (i.e., mimicry) may impair divergent thinking through perceived similarity. Mimicry is a related phenomenon to synchrony but with slightly delayed timing (Chartrand & Bargh, 1999). If mimicry impairs divergent thinking, it is likely that synchrony could as well. However, the relationship between group synchrony and creative thinking has not been examined (mimicry applies to dyads, and not to groups larger than two). The present paper focuses on synchrony's effects on creative thinking.

Effects of Physical Intensity

Cohesion. Physical intensity has been found to influence the positive relationship between exercise and cohesion. For example, Prapavessis and Carron (1997) found a positive association between intensity and feelings of cohesion among athletes. One explanation for the positive social effects of exercise involves the stimulation of a neurobiological system – the so-called endogenous system. Exercise activates the endogenous system which releases endogenous opioids (Boecker et al., 2008) and endocannabinoids (Raichlen et al., 2013), which are our body's natural morphine- and cannabis-producing systems respectively. This release of endogenous opioids and endocannabinoids has been implicated as an evolutionarily adaptive function of exercise to motivate and sustain foraging with our ancestors (Davis, Taylor, & Cohen, 2015; Raichlen et al., 2013). Endogenous opioids, specifically endorphins, have been linked to social bonding behaviour of mammals – human and non-human – such as grooming and infant attachment, due to the association of endorphins to liking, affiliation, and reward systems (Machin & Dunbar, 2011).

Positive affect. Exercise has consistently been shown to improve mood and well-being. Plante and Rodin (1990) and Yeung's (1996) reviews of exercise's effects on psychological health and mood state showed that exercise increases psychological well-being and positive mood overall, and reduces depression and anxiety. The endorphins released by the endogenous system also stimulate feelings of euphoria and happiness. The analgesic effect of endorphins is popularly called the "runner's high" (Holden, Jeong, & Forrest, 2005). Boecker and colleagues (2008) found that participants self-reported significantly higher ratings of happiness and euphoria after exercise. Using PET ligand activations to further understand the mechanisms of the endogenous opioid system, they found changes in specific brain regions associated with the endogenous system (i.e., prefrontal and limbic/paralimbic) after more intense exercise. Boecker and colleagues suggested that the endocannabinoid system, which elicits a state of calmness, positive affect, and analgesia, plays an important role in mediating physiological responses to exercise. Sparling, Giuffrida, Piomelli, Rosskopf, and Dietrich (2003) found that levels of anandamide, a chemical released from the endocannabinoid system, significantly increased from before exercise to after exercise for runners and cyclists, but there was no change in anandamide levels for control participants who did not exercise. Collectively, these studies suggest the important role this system plays for exercise's effects on positive affect.

Nevertheless, the effects of physical intensity on mood are varied. Activities with moderate physical intensity levels (e.g., aerobic exercises such as jogging; DiLorenzo et al., 1999) and higher physical intensity levels (e.g., anaerobic exercises such as weight-lifting; Doyne et al., 1987) have been shown to facilitate psychological well-being over time. However, low intensity activities (e.g., tai chi) have also been shown to facilitate well-being, and reduce anxiety and stress (Jin, 1992). At this moment, it is unclear what may explain these differing effects. This points to the need for more studies separating the effects of intensity levels on positive and negative affect.

Creative thinking. Exercise has been shown to enhance cognitive processes (e.g., creative thinking, decision-making, problem-solving) when assessed after moderately intense exercise (Chang et al., 2012). Most studies investigating the relationship between exercise and creative thinking (mostly using divergent thinking tasks) have found a positive relationship. Gondola (1986, 1987) found that exercise, both running and aerobic dance, positively influenced divergent thinking. A decade

later, Steinberg et al. (1997) found that after aerobic exercises, participants produced more diverse categories of ideas in a divergent thinking task. They suggested that these positive effects of exercise on divergent thinking last for prolonged durations after the exercise, and are not restricted to single bouts of acute exercise. Yet, the relationship between intensity and creative thinking appears inconsistent. For instance, Chang et al.'s (2012) meta-analysis showed that moderately intense exercises facilitate executive function tasks including creative thinking. But Colzato and colleauges (2013) found that participants produced more diverse categories of ideas during the rest period compared to periods of moderate and intense exercise. They attributed the result to participants' fitness levels. For participants with high fitness levels, highly intense exercise facilitates creative thinking. But for participants with low fitness levels, highly intense exercise impairs creative thinking. Such discrepancy requires further assessment.

The positive effects of exercise on creative thinking may be due to the increasing blood flow and activation in the brain during exercise. Specifically, exercise may positively affect cognitive functioning over time by increasing activity in neural networks in brain regions that are crucial to learning and memory, such as the prefrontal cortex (Gomez-Pinilla & Hillman, 2013). Erickson and colleagues (2011) showed that over a year, participants involved in regular moderate intensity aerobic exercise had increased hippocampal volume compared to the control group who only did stretching and toning exercises, and this increase led to an improvement in memory performance.

Current Studies

The empirical literature investigating synchrony and physical intensity do not clarify the processes by which these two factors jointly or independently influence cohesion, positive affect, and creative thinking. In the current paper, we aimed to examine the effects of synchrony and intensity on each of these outcomes to clarify some of these relationships. We did this by conducting a field study in a naturalistic environment, and a follow up experimental study to control for some methodological constraints of the field study.

Study 3 (Field Study)

There are only a handful of studies that have examined the effects of naturally occurring synchronous activities (e.g., Fischer et al., 2013; Xygalatas et al., 2013). We conducted a field study on a phenomenon that had varying levels of both synchrony and intensity – group exercises. We examined the effects that different group exercises had on cohesion, positive and negative affect, and divergent thinking as a creative thinking component. We hypothesised that synchrony would have a positive effect on cohesion and positive affect, and would be associated with lower negative affect and divergent thinking. Moreover, we hypothesised, in line with current exercise literature, that intensity would have a positive effect on cohesion and positive affect, and also divergent thinking.

Method

57 participants were recruited from various groups at a large university in New Zealand (44 females; mean age = 24.54 years, *SD* = 7.80 years, range = 18-56 years) via recruitment posters and announcements at the recreation centre and at lectures. Each participant received a chocolate bar and a NZD20 supermarket voucher for their participation[3].

To assess degrees of synchrony in participants' movements, we followed a protocol adopted from Fischer et al. (2013). A student research assistant wrote down her observations of participants' movements every five minutes during the activity, and noted how synchronised the movements were. Based on these observations, three independent coders rated each activity on whether it was highly synchronised, somewhat synchronised, or not synchronised. The control condition of attending lectures was coded as no movement. The duration of the activities ranged from 50 minutes to 1.5 hours. Table 5.1 denotes the number of participants and description for each activity.

[3] Studies 3 and 4 were approved by the university's Human Ethics Committee (ID: RM019282). All participants provided written consent.

Table 5.1

Number of Participants and Description for Each Activity Based on Synchronicity

Synchronicity	*n*	Activity	Description
No movement	13	Control	Attend lectures
Not synchronised	6	Taekwondo	Korean martial arts
Not synchronised	9	Yoga	Exercise with different postures and flowing movements (typically in rhythm with a person's breathing)
Somewhat synchronised	9	Capoeira	Afro-Brazilian martial arts involving joint music activities
Somewhat synchronised	8	Pilates	Exercise with controlled and flowing movements
Highly synchronised	12	Zumba	Latin dance-infused group aerobics exercise
Total (*N*)	57		

We measured heart rate (HR) as a proxy of physical intensity. Participants wore a Polar Team 2 HR monitor (Polar Electro Oy, Kempele, Finland) throughout the activity which recorded their HR every second. HR data, which was stored in the monitors, was uploaded to a processing computer and processed with the Polar Team 2 Software Version 1.4.5 (Polar Electro Oy, Kempele, Finland) upon completion of the study. We calculated the maximum HR percentage for each participant using the formula HR Maximum = 205.8 – (0.685*age) (Robergs & Landwehr, 2002). We used participants' mean HR during the activity and compared that to their respective age-dependent maximum HR to obtain a percentage. In the analyses, we used the scaled (by group-mean centering) HR percentage as a measure of physical intensity.

Immediately after the activity, participants completed a survey. We measured cohesion using Reddish et al.'s (2013) adapted version of Aron et al.'s (1992) Inclusion of Other in the Self scale (IOS). We used the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) to measure participants' positive (Cronbach's $\alpha = 0.72$) and negative affect ($\alpha = 0.86$). We assessed divergent thinking as a measure of creative thinking using Guilford's (1967) Alternate Uses Task (AUT). Participants were instructed to list as many uses as they could for two items; a newspaper and a brick. To

assess participants' responses, we used the Consensual Assessment Technique (CAT; Amabile, 1982) which has been described as the 'gold-standard' technique to assess creativity tasks such as the AUT (Baer & McKool, 2009). Two independent coders rated the responses on a scale from 1 (not at all) to 7 (very much) on two divergent thinking indices; creativity and novelty. We included a third index of fluency (the total number of responses from each participant). The inter-rater reliabilities were 0.74, 95%CI [0.69, 0.78] for creativity, and 0.66, 95%CI [0.60, 0.71] for novelty ratings. With the acceptable reliability range being 0.70 to 0.90 (Baer & McKool, 2009), we considered the reliabilities acceptable for creativity and marginally acceptable for novelty ratings. Finally, we included two control questions because the activities were pre-existing groups. We asked participants of the duration of their involvement with their respective group activities, and how often they interacted with people from their group outside the activity to control for interactions amongst participants (familiarity effects). We also included age and gender as demographic items (see Part C.1 of Appendix C for example items).

Results and Discussion

To adjust for statistical non-independence of responses arising from dynamics unique to specific groups (producing nested data), we used a multilevel model to test the hypotheses using the *multilevel* (Bliese, 2016) and *nlme* (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2017) packages in R Version 3.3.1 software (R Core Team, 2016)[4]. Synchronicity rating and physical intensity (scaled HR percentage) were entered as fixed-effects predictor variables. Membership in the group activity was a random-effect nesting variable (e.g., participants from two separate yoga sessions were combined to form the yoga activity as a whole). The dependent variables were cohesion, affect, and divergent thinking.

We assumed all outcomes except fluency to be sampling from Gaussian distributions. To model the fluency index in divergent thinking, we assumed responses to be sampling from a Poisson distribution, which is an appropriate distribution for rate parameters. For each dependent variable, we examined if any of the control variables of age, sex, duration of involvement in the activity, and interaction among participants had

[4]The R code for the field study is available in Part C.4 of Appendix C.

a statistically significant effect. For testing our hypotheses, we then only included the control variables that had a significant effect on the dependent variable to make the model more parsimonious. Part C.3 of Appendix C displays the model estimates table in Table C.3.

Cohesion

Analysis on the control variables showed an effect of previous interactions among participants on cohesion, $\beta = 0.29$, $se = 0.13$, $p = .034$. This indicates that the more people interact with each other, the more cohesive they tend to feel as a group. No other statistically significant effects were found for the other control variables ($p_{max} = .823$). Controlling for interaction, the main effect of synchrony on cohesion was not statistically significant, $\beta = -0.16$, $se = 0.32$, $p = .635$. However, the results showed a statistically significant positive main effect of intensity on cohesion ratings, $\beta = 0.68$, $se = 0.32$, $p = .040$. Greater physical intensity was associated with more social cohesion, but we did not find the expected relationship between synchrony and cohesion.

Affect

Age was positively associated with positive affect, $\beta = 0.03$, $se = 0.02$, $p = .033$. No other statistically significant effects were found for the other control variables ($p_{max} = .967$). Controlling for age, the results showed that neither synchrony, $\beta = 0.21$, $se = 0.17$, $p = .290$, nor intensity, $\beta = 0.12$, $se = 0.17$, $p = .485$, were associated with positive affect.

There were no statistically significant effects of the control variables on negative affect ($p_{max} = .903$), and thus the control variables were not included in the following analyses. We did not find a main effect of either synchrony, $\beta = -0.16$, $se = 0.20$, $p = .462$, nor intensity, $\beta = 0.21$, $se = 0.22$, $p = .329$, on negative affect ratings. Overall, we did not find the expected relationships between either synchrony or intensity with affect.

Divergent Thinking

Each of the three divergent thinking indices (i.e., fluency, creativity, and novelty) were analysed separately.

Fluency. In the analysis of control variables, age had a positive effect on fluency, β = 0.01, *se* = 0.01, *p* = .027, and involvement duration with the activity had a negative effect on fluency, β = -0.01, *se* = 0.00, *p* = .037. Controlling for age and involvement duration, the results showed that synchrony had a statistically significant negative main effect on fluency, β = -0.26, *se* = 0.07, *p* < .001. Physical intensity had a statistically significant positive main effect on fluency, β = 0.26, *se* = 0.08, *p* = .001.

Creativity index. The control variables had no statistically significant effects on creativity ratings (p_{max} = .988). The results showed that synchrony decreased creativity ratings, β = -0.29, *se* = 0.11, *p* = .053. Physical intensity had a positive main effect on creativity ratings, but the effect was marginal, β = 0.22, *se* = 0.12, *p* = .060.

Novelty index. Similar to the creativity index, the control variables had no statistically significant effects on novelty ratings (p_{max} = .842). The results showed that synchrony decreased novelty ratings, β = -0.28, *se* = 0.10, *p* = .046, and physical intensity increased novelty ratings, β = 0.25, *se* = 0.11, *p* = .021. Altogether, highly synchronous exercises impair divergent thinking, but highly intense exercises facilitate divergent thinking.

Study 4 (Experimental Study)

While Study 3's field study leveraged ecologically valid evidence to investigate the hypothesised relationships between both synchrony and physical intensity on cohesion, affect, and creative thinking, this naturalistic approach had its limitations. The time constraints of the field study restricted the number of items we could include for each dependent measure in the survey. Furthermore, we used the observation of a research assistant to evaluate levels of synchrony. Moreover, given the varied movements in such activities, it was not feasible to track all relevant elements of body synchronisation using simple subjective ratings. In short, unavoidable features of the ecological data prevented precise measurements of behavioural synchrony. To address these limitations, Study 4 used an established experimental paradigm to investigate synchrony and intensity's effects on the three outcomes.

In laboratory experiments, synchronous movements are manipulated. However, synchronised actions in natural ecologies often occur with a shared purpose (Reddish et

al., 2013; Tomasello et al., 2005). Tomasello and colleagues (2005) argued that shared purpose, or shared intentionality, creates coordinated actions and also coordinated mental states, which leads to positive prosocial behaviours. Reddish et al. (2013) found that shared intentionality amplified the positive effects of synchronised actions on interdependent self-construal, by providing a group of participants with the shared goal of synchronising their actions together. It is possible that having a shared purpose might create shared mental states which allow the integration of others in how individuals view themselves (i.e., more interdependent self-construal). This might lead to more conformity in thought (Hu et al., 2017), stifling the generation of numerous ideas (i.e., divergent thinking). However, it is also possible that conformity of thought could facilitate convergent thinking by increasing the motivation to search for a single correct solution.

Therefore, Study 4 employed an experimental paradigm with varied synchronised movements to test how shared intentionality interacts with physical intensity to affect cohesion, mood, and creative thinking (assessed with both divergent and convergent thinking). Based on Reddish et al.'s (2013) synchrony study with shared intentionality, and Ashton-James and Chartrand's study (2009), we hypothesised that having a group goal (shared intentionality) would have a positive effect on cohesion, positive affect, and convergent thinking, but that it would also have a negative effect on divergent thinking. Similar to Study 3, we hypothesised that intensity will have a positive effect on cohesion, positive affect, divergent thinking, and convergent thinking.

Method

Participants

90 participants were recruited through posters placed around a New Zealand university campus and via Facebook (63 female; mean age = 22.82 years, *SD* = 4.99 years, range = 18-48 years). Participants were randomly assigned to one of six conditions with an equal number of participants in each condition (n = 15). We used this sample size because previous studies had used similar sample sizes (Reddish et al., 2013). Each participant received a chocolate and a NZD10 supermarket voucher. They were also given the opportunity to enter into a draw to win a NZD50 Amazon.com voucher if they were interested.

Design

The study employed a 3 (Intensity) x 2 (Goal) between-subjects factorial design with cohesion, affect, and creative thinking as dependent variables. The intensity levels were induced through different physical movements. In groups of three, participants either performed jumping jacks, marched on the spot, or breathed while standing still, to induce high, moderate, and low intensity levels respectively. All three movements were performed for five minutes in exact synchrony, meaning participants performed identical actions at the same time and speed with each other (see Part C.2 of Appendix C for a description of the instructions).

Using the shared intentionality manipulation from Reddish et al.'s (2013) experiment 3, the two goal manipulation levels were individual goal and group goal. Participants in the individual goal conditions were instructed to perform movements according to metronome beats they heard from a computer, and to "move in time with the beats". Participants in the group goal conditions were instructed to perform movements according to metronome beats they heard for the first 30 seconds, after which the beats stopped playing and they were told to continue to "work together to perform the movements in time with each other" for the remaining duration. To increase the salience of the goals, participants were told their performances were being video recorded to assess individual performances in the individual goal conditions, and assess group performances in the group goal conditions.

Procedure and Materials

We provided participants with instructions regarding their respective intensity and goal manipulations, and they performed the movements for five minutes. Immediately after performing the movements, we asked participants to rate how physically intense their respective movement activities were on a 7-point Likert scale ranging from 1 (not at all intense) to 7 (very intense) with a mid-point of 4 (moderately intense). Each participant also wore a Polar Team 2 HR monitor so we could examine their HR during the movement manipulation.

Then participants completed a survey of demographic items (i.e., age and gender), manipulation checks, cohesion, affect, and did two creative thinking tasks. Due to caffeine possibly affecting heart rate measurements and affective responses, we asked participants if they had consumed any caffeinated beverages for that day, and how many cups if they did. To control for familiarity, we asked participants to rate how well they

knew each of the other participants before the study. An assessment of the mean scores for each condition showed that most participants had not seen each other before, and there were no significant differences between conditions, $F_{max} = 2.01$, $p = .160$. The presentation order of the survey and creative thinking tasks was counterbalanced to control for order effects, as was the presentation order of the two creative thinking tasks.

Cohesion was measured as a composite of four constructs – interconnectedness, entitativity, trust, and perceived similarity (explained 38.13% of variance, $\alpha = 0.92$). The PANAS was used to measure participants' positive ($\alpha = 0.74$) and negative affect ($\alpha = 0.80$). Creative thinking was assessed with both divergent and convergent thinking. We use the AUT to assess divergent thinking with the same items, instructions, and assessment technique as in Study 3. The inter-rater reliabilities were 0.72, 95%CI [0.70, 0.75] for creativity, and 0.69, 95%CI [0.66, 0.72] for novelty ratings. Convergent thinking was assessed using the Remote Associates Test (RAT; Mednick, 1962). Participants were presented with 10 items. Each item contained a set of three unrelated clue words. Participants were required to fill in a fourth word that was independently associated to all three words. For example, for the words "light", "birthday", and "stick", the fourth associated word was "candle". At the end of the survey, participants were asked two open ended questions on whether they guessed the aim of the study. None of the participants correctly guessed the aim of the study, and therefore all participants were all included in the analyses.

Results and Discussion

The analyses for all the dependent variables were conducted with a 3 x 2 Analysis of Variance (ANOVA) with Intensity and Goal as the independent variables. Table 5.2 shows the means and standard deviations for each condition.

Manipulation Checks

We found a statistically significant main effect of intensity, $F(2, 84) = 5.62$, $p = .005$, $\eta_p^2 = 0.12$, on self-reported movement intensity ratings. Participants doing jumping jacks (high intensity) found the movements to be more physically intense ($M = 3.57$, $se = 0.25$) compared to participants who marched (moderate) and breathed (low) on the spot (both $M = 2.53$, $se = 0.25$, $p = .014$). Although the self-reported ratings for the moderate and low intensity conditions did not differ statistically, the ANOVA on

participants' physiology showed a statistically significant main effect of intensity on mean HR during the movement manipulation, $F(2, 84) = 72.01$, $p < .001$, $\eta_p^2 = 0.63$. Participants in the high intensity condition had statistically significantly higher mean HRs ($M = 137.28$, $se = 2.76$) compared to the moderate ($M = 110.10$, $se = 2.76$, $p < .001$) and low conditions ($M = 90.62$, $se = 2.76$, $p < .001$), and the moderate and low conditions were statistically significantly different as well ($p < .001$), indicating that our movement manipulation was successful.

Participants given a group goal ($M = 3.16$, $se = 0.21$) reported the movements to be more physically intense compared to the individual goal ($M = 2.60$, $se = 0.21$), $F(1, 84) = 3.66$, $p = .059$, $\eta_p^2 = 0.04$, which was also reflected in the HR analysis, $F(1, 84) = 5.79$, $p = .018$, $\eta_p^2 = 0.06$, ($M_{group} = 116.50$, $se = 2.26$; $M_{individual} = 108.83$, $se = 2.26$). This was due to the gradual increase in movement speed in the group goal conditions compared to the reliance on a steady metronome beat for participants in the individual goal conditions.

Cohesion

We found a statistically significant main effect of goal on cohesion, $F(1, 84) = 6.97$, $p = .010$, $\eta_p^2 = 0.08$. Participants felt more cohesive when provided with a group goal of working together ($M = 4.06$, $se = 0.12$) compared to an individual goal of focusing on their own movements ($M = 3.63$, $se = 0.12$). We did not find a statistically significant main effect of intensity on cohesion, $F(2, 84) = 1.75$, $p = .181$, $\eta_p^2 = 0.04$, nor an interaction effect of intensity and goal on cohesion, $F(2, 84) = 0.21$, $p = .808$, $\eta_p^2 = 0.01$.

Affect

The ANOVA did not reveal statistically significant main effects of intensity on positive affect, $F(2, 84) = 0.79$, $p = .458$, $\eta_p^2 = 0.02$, nor of goal on positive affect, $F(1, 84) = 0.40$, $p = .528$, $\eta_p^2 = 0.01$. The intensity and goal interaction on positive affect was not statistically significant, $F(2, 84) = 1.68$, $p = .192$, $\eta_p^2 = 0.04$.

For negative affect, we did not find statistically significant main effects of intensity, $F(2, 84) = 0.89$, $p = .414$, $\eta_p^2 = 0.02$, or goal, $F(1, 84) = 1.07$, $p = .303$, $\eta_p^2 = 0.01$, nor an interaction effect, $F(2, 84) = 0.78$, $p = .461$, $\eta_p^2 = 0.02$. Overall, we did not find the expected relationships between shared intentionality and intensity on affective responses.

Table 5.2

Means and Standard Deviations (in parentheses) of Each Condition in Study 4

Dependent Variables	High intensity		Moderate intensity		Low intensity	
	Group	Individual	Group	Individual	Group	Individual
Cohesion	4.13 (1.09)	3.80 (0.65)	3.92 (0.83)	3.33 (0.68)	4.14 (0.69)	3.75 (0.70)
Positive affect	4.43 (0.93)	3.83 (0.97)	3.66 (1.25)	4.00 (1.16)	4.14 (0.86)	4.00 (0.72)
Negative affect	2.00 (0.87)	1.49 (0.65)	2.20 (1.27)	1.95 (1.14)	1.92 (0.69)	2.04 (1.07)
Convergent thinking	3.53 (1.85)	4.67 (2.53)	3.80 (2.40)	2.73 (2.25)	2.40 (1.99)	4.07 (2.34)
Fluency	17.40 (3.18)	19.40 (4.60)	15.13 (4.49)	16.40 (5.14)	16.47 (4.98)	15.67 (5.02)
Creativity	3.31 (0.34)	3.39 (0.50)	3.21 (0.39)	3.31 (0.62)	3.19 (0.57)	2.97 (0.36)
Novelty	3.66 (0.36)	3.76 (0.54)	3.59 (0.33)	3.61 (0.62)	3.55 (0.63)	3.28 (0.35)

Creative Thinking

Convergent thinking. We did not find statistically significant main effects of intensity, $F(2, 84) = 1.44$, $p = .242$, $\eta_p^2 = 0.03$, nor goal, $F(1, 84) = 1.50$, $p = .224$, $\eta_p^2 = 0.02$. However, the intensity and goal interaction effect on the RAT was statistically significant, $F(2, 84) = 3.14$, $p = .048$, $\eta_p^2 = 0.07$. Pairwise comparisons revealed marginal differences between intensity levels in the individual goal conditions, $F(2, 84) = 2.93$, $p = .059$, $\eta_p^2 = 0.07$. Participants performing highly intense movements individually had significantly higher RAT scores ($M = 4.67$, $se = 0.58$) than participants performing moderately intense movements ($M = 2.73$, $se = 0.58$, $p = .020$). The RAT scores for participants in the low intensity condition ($M = 4.07$, $se = 0.58$) did not significantly differ from high ($p = .465$) or moderate intensity conditions ($p = .107$). Not having a shared purpose while exercising at high intensity appears to facilitate convergent thinking.

However, the difference between intensity levels was not statistically significant for participants who were given group goals, $F(2, 84) = 1.65$, $p = .197$, $\eta_p^2 = 0.04$. Nevertheless, it is important to note that the trend of the results was different in the group goal conditions. Participants performing moderately intense movements with a shared goal had higher RAT scores ($M = 3.80$, $se = 0.58$) compared to participants in the high intensity ($M = 3.53$, $se = 0.58$), and low intensity conditions ($M = 2.40$, $se = 0.58$).

Divergent thinking. Similar to Study 3, each divergent thinking index was analysed separately.

Fluency. We found a marginal main effect of intensity on fluency, $F(2, 84) = 2.93$, $p = .059$, $\eta_p^2 = 0.07$. The main effect of goal, $F(1, 84) = 0.71$, $p = .401$, $\eta_p^2 = 0.01$, and the intensity and goal interaction effect, $F(2, 84) = 0.74$, $p = .479$, $\eta_p^2 = 0.02$, were not statistically significant. Although not statistically significantly different after Bonferroni correction, participants in the high intensity condition nevertheless provided more responses to the AUT ($M = 18.40$, $se = 0.84$), compared to participants in the moderate ($M = 15.77$, $se = 0.84$, $p = .090$) and low intensity conditions ($M = 16.07$, $se = 0.84$, $p = .161$).

Creativity index. The results revealed a marginal main effect of intensity on creativity ratings, $F(2, 84) = 2.53$, $p = .085$, $\eta_p^2 = 0.06$. The main effect of goal, $F(1, 84) = 0.02$, $p = .892$, $\eta_p^2 < 0.01$, and intensity and goal interaction effect on creativity ratings were not statistically significant, $F(2, 84) = 1.02$, $p = .367$, $\eta_p^2 = 0.02$. Post-hoc

analyses showed that participants performing highly intense movements produced AUT responses that were marginally more creative (M = 3.35, se = 0.09) compared to the low intensity condition (M = 3.08, se = 0.09, p = .088). There were no statistically significant differences in creativity ratings from participants in the moderate intensity condition (M = 3.26, se = 0.09) compared to high (p = 1.000), or low intensity conditions (p = .448).

Novelty index. Similar to the creativity index, we found a marginal main effect of intensity on novelty ratings, $F(2, 84) = 2.88$, p = .062, η_p^2 = 0.06. The main effect of goal, $F(1, 84) = 0.24$, p = .622, $\eta_p^2 < 0.01$, and intensity and goal interaction effect on novelty ratings, $F(2, 84) = 1.16$, p = .320, η_p^2 = 0.03, were not statistically significant. Post-hoc analyses revealed that participants in the high intensity condition produced AUT responses that were marginally more novel (M = 3.71, se = 0.09) compared to the low intensity condition (M = 3.42, se = 0.09, p = .059). There were no statistically significant differences in novelty ratings from participants in the moderate intensity condition (M = 3.60, se = 0.09) compared to high (p = 1.000), or low intensity conditions (p = .446). Overall, highly intense movements appear to facilitate divergent thinking.

General Discussion

Study 3 examined how synchronised actions and physical intensity influenced cohesion, positive affect, and creative thinking in a field study of naturally occurring synchronised actions. Study 4 examined the interaction between shared intentionality of synchronised actions and physical intensity due to the amplified social effects of shared intentionality, and the possibility that shared intentionality creates coordinated mental states which affect creative thinking.

Effects on Cohesion

Results of Study 3 did not support the hypothesis that synchrony affects cohesion. However, Study 4 found that shared intentionality increases cohesion. Having a shared goal of working together to perform synchronous movements at the same time with others has been shown to increase feelings of cohesion among members (see Reddish et al., 2013), which shows the importance of shared intentionality in amplifying synchrony's positive social bonding effect. Performing matching movements with

others, particularly when working together to perform them, is potentially important in suppressing self-other boundaries which allows for positive social bonding effects.

Study 3's result suggests that physical intensity's effect on cohesion is apparent in naturally occurring exercises that last between an hour to 1.5 hours, in contrast with Study 4's result using a much shorter time interval for the movement activity. This implies that a five-minute exercise induction might not be enough to produce this social bonding effect. When exercising for longer durations in the field study, participants exercising at higher intensity levels reported feeling more interconnected with others after the exercise. An implication here is that exercise's activation of the endogenous system may require a longer duration of physical movement. Previous studies investigating the activation of endogenous opioids and endocannabinoids had participants exercising for at least 10 minutes (e.g., Tarr et al., 2015), with most studies exceeding 30 minutes or more (e.g., Boecker et al., 2008; Davis et al., 2015).

Affective Responses

Both Study 3 and 4 failed to replicate previous findings that synchrony and intensity increase positive affect, and decrease negative affect. Nevertheless, it is possible that in our studies, the act of exercising together regardless of synchronicity and intensity level, was sufficient to elicit an increase in positive affect for all participants. Durkheim's collective effervescence hypothesis encompasses a myriad of ritualistic activities, and are most likely not specific to highly synchronous and highly intense physical activities. In support of this, Mogan et al.'s (2017) meta-analysis showed that performing actions with others regardless of synchronicity was sufficient to increase positive affect. Moreover, studies have shown that most forms of exercise have positive effects on positive affect (Plante & Rodin, 1990; Yeung, 1996).

Creative Thinking Responses

It has been speculated that synchronous actions would lead to conformity of thought and less divergent thinking through increased cohesion, and this would be amplified by shared intentionality. Study 3's results showed that synchrony was a statistically significant negative predictor of divergent thinking, however Study 4 did not find a statistically significant main effect of shared intentionality on divergent thinking. These results suggest that highly synchronous exercises impair the generation of creative and novel ideas, but this effect is not amplified by having a shared purpose

(at least over such a short period of movement). In addition, we did not find a statistically significant effect of synchrony on cohesion in Study 3, indicating that synchronous actions may possibly affect creative thinking through a different mechanism. One mechanism which was not tested in this paper but could play a vital role in synchrony's effect on creative thinking is conformity. Durkheim's (1912/1995) conjecture was that ritualistic activities would lead to conformity of thought. It is likely that it is the conformity and induced group compliance from synchronous actions which leads to impaired divergent thinking, and not cohesion.[5] Providing some support to this hypothesis, Wiltermuth (2012a) showed that synchronous actions with a confederate led to more conformity in participants. It is plausible that this increased conformity from synchrony negatively effects divergent thinking.

Consistent with previous studies investigating the effects of exercise on divergent thinking (Gondola, 1986, 1987; Steinberg et al., 1997), we found that physical intensity had a main effect on divergent thinking in both Studies 3 and 4. Furthermore, we found an interaction between intensity level and shared intentionality for convergent thinking in Study 4. For participants who were given an individual goal, high intensity actions facilitated higher convergent thinking scores compared to moderate and low intensity actions. There were no statistically significant differences in convergent thinking scores when participants had shared group goals. Taken together, these results suggest that highly intense exercises facilitated both components of creative thinking, in the generation of more creative and novel ideas (i.e., divergent thinking), and the synthesising of ideas (i.e., convergent thinking). These results lend support to the positive effects exercise has on creative thinking. Even short bouts of physically intense exercise may activate the creative thinking potential of individuals. This has clear implications for educational scholars and practitioners.

Conclusion

We aimed to examine if synchronised activities with varying levels of physical intensity had an effect on social cohesion, positive affect, and creative thinking, by using the unique contributions of both a naturalistic field study and a controlled experimental paradigm. Based on the results of both of these studies, it is likely that the

[5] Cohesion was not significantly correlated to creative thinking outcomes in Studies 3 and 4 (see Tables C.1 and C.2 in Part C.3 of Appendix C).

mere act of performing actions or doing something with others regardless of synchronicity is sufficient to elicit cohesion and positive affect, and having shared intentionality only amplifies the effect on cohesion. The effect of intensity on social and affective outcomes, on the other hand, depends on the duration of the physical activity. Longer durations of physically intense activities have a positive effect on cohesion and positive affect, but very short bursts of activity may be insufficient to elicit these positive social and affective effects. More importantly, this paper presents what appears to be the first novel contribution to synchrony's relationship with creative thinking, with our results suggesting that synchrony impairs creative thinking. In contrast, highly intense activities facilitate creative thinking. Highly synchronous ritualistic behaviours may have evolved to be adaptive in social bonding, but not so much for some cognitive processes. Synchronised actions may have helped to maintain and stabilise conformity to the cultural system, explaining the widespread use of synchronised rituals in religious communities. However, exercise, specifically highly intense exercise, could have been adaptive for social bonding, well-being, and cognitive functioning. The results suggest that synchrony and intensity have independent and opposing effects on cognition. These differences appear to turn on synchrony's role in suppressing creativity, whereas, by contrast, exertion enhances creativity.

Chapter 6

General discussion

Overview

This thesis set out to investigate the effects of synchronous actions – a key feature of rituals – on social, affective, and cognitive dimensions of response. One of the aims of this thesis was to synthesise the existing literature on experimentally manipulated synchronous actions to determine synchrony's overall effects on various dimensions of response – namely prosocial behaviours, social bonding perceptions, positive affect, and cognitive processes. Another aim was to investigate the relationship between synchronous actions and creative thinking. I conducted four empirical studies employing different methodologies to achieve these two research aims.

In the following sections of this chapter, I present a comprehensive summary of the findings from the empirical studies on creative thinking, cohesion, and positive affect. Then, I discuss potential theoretical mechanisms that explain how synchronous actions could affect the three outcome variables. Finally, I discuss some limitations, provide recommendations for potential future research avenues, and offer practical implications of the findings.

Summary of Findings

The summary of findings will be split into subsections. First, I briefly discuss synchrony's overall effects on the four dimensions of response from Study 1. Then, I discuss synchrony's effects on creative thinking, cohesion, and affective responses. Studies 2, 3, and 4 assessed all three of these outcome variables. Hence, I conducted a mini meta-analysis on the responses from all three studies in order to provide a more systematic summary of the findings. Given the importance of shared intentionality and physical intensity, I included both variables in the mini meta-analysis. Therefore, for each of the three outcome variables, I examined this thesis's overall effects according to the three manipulated variables – synchrony, shared intentionality, and physical intensity.

Overall

To recap the main findings from the meta-analysis of synchrony's overall effects on different dimensions of response, the results showed that synchronous actions had a positive medium-sized effect on prosocial behaviours, and a positive small-sized effect on perceptions of social bonding, positive affect, and cognitive functions when compared to non-synchronous actions. Compared to control conditions (no movement or move alone), performing frequency-locked synchronous movements and vocalisations increased prosocial behaviours, social bonding perceptions, and positive affect. When compared to coordinated but asynchronous movements, synchrony increased prosocial behaviours, social bonding perceptions, and cognitive outcomes, but there was no statistically significant difference for positive affect. This suggests that to elicit positive affective responses, the actions do not require the exact matching in time. This supports Durkheim's (1912/1995) conjecture on collective effervescence, but is in conflict with Hobson et al.'s (2018) recent framework which argues that synchrony should increase positive affect, which I noted in the general introduction (Chapter 2).

Additionally, the size of the participating group moderates synchrony's effects on the four dimensions of response. Performing synchronous actions in larger groups were more effective in eliciting an increase in prosocial behaviour and positive affect. On the other hand, performing synchronous actions in smaller groups may be more effective in eliciting social and cognitive responses. These patterns hint at potential neurocognitive processes that may underlie synchrony's effects on these latter two responses, which will be discussed in the next subsection.

Mini Meta-analysis

I conducted mean effect size meta-analyses for each of the three manipulated variables (i.e., synchrony, shared intentionality, and physical intensity [comparing high intensity to moderate and low intensities]) separately, thus the analyses do not take into consideration interaction effects. In addition, for the synchrony and physical intensity manipulations, I also teased apart the individual conditions by conducting separate analyses for each comparison. I compared synchrony to asynchrony conditions, synchrony to control conditions (passive or no movement), and asynchrony to control conditions. For physical intensity, I compared high intensity to moderate intensity conditions, high intensity to low intensity conditions, and moderate intensity to low intensity conditions.

I used a fixed effects model to test the effects of each manipulated variable on the three outcome variables of creative thinking, cohesion, and positive affect. Similar to Study 1's meta-analysis, I report the effect sizes below as Pearson's correlation coefficient (*r*), and I conducted the analyses using the *metafor* package (Viechtbauer, 2010) in R Version 3.3.1 software (R Core Team, 2016). Table 6.1 reports the mean effect sizes for the overall synchrony, shared intentionality, and high physical intensity effects, as well as individual comparison effects for synchrony and intensity.

Creative Thinking: Divergent Thinking

Synchrony. Synchrony's overall mean effect size was a small negative effect for all three divergent thinking indices. Overall, synchrony had a marginally negative effect on fluency, M_{ES} = -0.12, *se* = 0.06, *p* = .058, *k* = 7, 95% CI [-0.25, 0.00], but there was no support for a statistically significant effect on the creativity index, M_{ES} = -0.03, *se* = 0.06, *p* = .609, *k* = 7, 95% CI [-0.16, 0.09], and the novelty index, M_{ES} = -0.03, *se* = 0.06, *p* = .627, *k* = 7, 95% CI [-0.16, 0.09].

I performed separate analyses to compare between the three different synchrony conditions (i.e., synchrony, asynchrony, and control). As shown in Table 6.1, there was no support for a statistically significant difference between synchrony and asynchrony for the fluency index, M_{ES} = -0.06, *se* = 0.09, *p* = .468, *k* = 4, 95% CI [-0.24, 0.11]. However, both the synchrony, M_{ES} = -0.19, *se* = 0.09, *p* = .046, *k* = 3, 95% CI [-0.37, -0.00], and asynchrony conditions, M_{ES} = -0.16, *se* = 0.08, *p* = .059, *k* = 4, 95% CI [-0.32, 0.01] had statistically significant and marginal negative effects respectively on fluency when compared to the control conditions. There was no support for statistically significant differences between the three synchrony conditions for the creativity and novelty indices, but the trend of the results showed that synchronous and asynchronous actions had a negative effect on both indices compared to the control condition.

Taken together, the trend of the results showed that synchronous actions had a negative effect on divergent thinking compared to asynchronous actions and the control conditions. Asynchronous actions also had a negative effect on divergent thinking compared to the control conditions. In support of my predictions, and similar to Ashton-James and Chartrand's (2009) study on mimicry's effect on divergent thinking, performing movements in synchrony or asynchrony appears to impair divergent thinking.

Shared intentionality. The results did not support statistically significant differences between group goal conditions and individual goal conditions. Nevertheless, the trend showed that participants in the group goal conditions generated more responses in the AUT, but these responses were rated as less creative and novel compared to the responses from participants in the individual goal conditions. However, these effect sizes were very small, ranging from -0.04 to 0.01. Based on Tomasello et al.'s (2005) argument that shared intentionality fosters shared mental states, it is likely that these shared mental states inhibit the generation of creative and novel ideas.

Another possible explanation for these results is the social facilitation effect, which refers to "an individual's reaction, usually in the context of task performance, to being in the presence of others" (Uziel, 2010, p. 1592). Zajonc (1965) stated that an individual's performance can be enhanced in the presence of others if the task at hand is simple or easy. But if the task at hand is complex or difficult, an individual's performance can be impaired in the presence of others. Zajonc (1965) distinguished between the co-action effect (performing actions with others), and the audience effect (the individual's performance being observed by others) of social facilitation. It is possible that having the group goal of performing together (i.e., co-action), which required group members to pay attention to perform body movements with each other, may have induced social facilitation effects. While participants in the group goal condition had a higher production of responses (i.e., the easier task), generating more creative and novel responses is more difficult to do, hence the lower creativity and novelty scores. On the other hand, participants who were given an individual goal were asked to focus their attention on only themselves which meant that they did not have to pay attention to each other even though they performed actions in the same room. Hence, their performance may not have been affected by the social facilitation effect.

Intensity. Overall, when compared to the other two conditions, the high intensity conditions had a statistically significant small positive effect on fluency, M_{ES} = 0.20, *se* = 0.08, *p* = .013, *k* = 5, 95% CI [0.04, 0.36], and novelty, M_{ES} = 0.17, *se* = 0.08, *p* = .034, *k* = 5, 95% CI [0.01, 0.33], and a marginal positive effect on creativity M_{ES} = 0.14, *se* = 0.08, *p* = .074, *k* = 5, 95% CI [-0.01, 0.30].

Breaking down the overall effects further, the results showed that participants in high intensity conditions generated statistically significantly more responses compared to participants in moderate intensity conditions, M_{ES} = 0.30, *se* = 0.14, *p* = .030, *k* = 2,

95% CI [0.03, 0.56]. Although the responses were also more creative and novel for participants in high intensity conditions, these comparisons were not statistically significant. Although not statistically significant (except for the high intensity versus low intensity novelty index comparison), the overall trend of the results showed that participants in high intensity and moderate intensity conditions generated more responses which were also more creative and novel when compared to low intensity conditions.

The literature does not reach a consensus on the effect of physical intensity on divergent thinking. Chang et al.'s (2012) meta-analysis showed that moderate levels of exercise intensity facilitated executive functions which included divergent thinking measures. However, Colzato et al.'s (2013) study showed that physical activity at high and moderate intensity levels impaired divergent thinking. Part of this discrepancy could be due to Chang et al.'s meta-analysis pooling together various cognitive processes under the umbrella of executive functions. My results provide some initial resolution to this discrepancy by showing that highly intense activities facilitate divergent thinking.

Creative thinking: Convergent Thinking

Synchrony. There was no support for a statistically significant effect of synchrony's overall mean effect size on convergent thinking, M_{ES} = 0.01, *se* = 0.08, *p* = .857, *k* = 4, 95% CI [-0.14, 0.16]. Additionally, the mean effect sizes did not differ much across the three conditions (i.e., mean effect sizes for the comparisons across conditions ranged from 0.00 to 0.03). The results suggest that even if there are synchrony effects, they are likely to be small. This is inconsistent with Ashton-James and Chartrand's (2009) study which found that mimicry facilitated convergent thinking.

Shared intentionality. Shared intentionality was found to have a small negative effect on convergent thinking, although this effect was not statistically significant, M_{ES} = -0.08, *se* = 0.07, *p* = .220, *k* = 6, 95% CI [-0.22, 0.05]. Participants in the individual goal conditions had higher mean scores on the RAT than participants in the group goal conditions. Unlike the aforementioned argument from Tomasello et al. (2005) that shared intentionality fosters shared mental states which could also facilitate the convergence of thought processes, the results showed that not having a shared goal or purpose may facilitate convergent thinking.

Similar to the divergent thinking results, having a group goal may have induced the social facilitation co-action effect on the convergent thinking task (i.e., the RAT). The RAT is a rather challenging task which requires participants to form associations from unrelated concepts. This cognitively difficult task may have inhibited the performance of participants in the group goal conditions, leading to lower scores on the RAT.

Intensity. Overall, the high intensity conditions had a statistically significant small positive effect on convergent thinking when compared to moderate and low intensity conditions, M_{ES} = 0.19, *se* = 0.10, *p* = .053, *k* = 4, 95% CI [-0.00, 0.37]. Participants in the high intensity conditions had higher convergent thinking scores compared to participants in the other two intensity conditions. The existing literature on physical intensity has focused on divergent thinking, and not convergent thinking, as a component of creative thinking. Hence, there is limited evidence for the association between physical intensity and convergent thinking. Colzato et al. (2013) investigated the effect of physical intensity on convergent thinking, and found that the relationship was dependent on the fitness level of the participants. For athletes, the authors found a marginal effect of high intensity exercise facilitating convergent thinking. However, for non-athletes, high intensity exercise impaired convergent thinking. While we did not assess the fitness level of participants, the results found in this thesis provide additional evidence that high physical intensity may enhance convergent thinking.

Cohesion

Synchrony. Next I report the results for perceptions of cohesion. Since the meta-analysis in Study 1 reported synchrony's overall effect on cohesion, the findings from this mini meta-analysis can be directly compared to the results of the meta-analysis reported in Study 1.

When compared to asynchrony and control conditions, the results showed that synchrony had a statistically significant small positive effect on cohesion, M_{ES} = 0.12, *se* = 0.06, *p* = .055, *k* = 7, 95% CI [-0.00, 0.25]. This is slightly smaller to the overall mean effect size of synchrony on perceptions of social bonding (M_{ES} = 0.17) reported in Study 1. Similar to Study 1, participants in the synchrony conditions reported statistically significantly higher cohesion scores compared to participants in the control conditions, M_{ES} = 0.28, *se* = 0.09, *p* = .003, *k* = 3, 95% CI [0.09, 0.46]. However, in

contrast to Study 1's results that synchrony increased cohesion over and above non-synchronous coordinated actions, the results of the thesis's mini meta-analysis found no statistically significant support for the difference between the synchrony and asynchrony conditions in cohesion ratings, M_{ES} = -0.01, *se* = 0.09, *p* = .866, *k* = 4, 95% CI [-0.19, 0.16]. Additionally, participants in the asynchrony conditions reported statistically significantly higher cohesion scores when compared to participants in the control conditions, M_{ES} = 0.29, *se* = 0.08, *p* = .001, *k* = 4, 95% CI [0.12, 0.45]. While not entirely consistent with Study 1's meta-analysis, the results of this thesis overall are similar to that of other researchers who have failed to replicate synchrony's positive cohesion effect (Baimel et al., 2018; Schachner & Garvin, 2010). Perhaps the act of performing actions in some situations may be sufficient to elicit social cohesion effects without the need for frequency-locked synchrony.

Shared intentionality. Although no statistically significant support was found, participants in the group goal conditions reported feeling more cohesive with their group members compared to participants in the individual goal conditions, M_{ES} = 0.11, *se* = 0.07, *p* = .108, *k* = 6, 95% CI [-0.02, 0.24]. Similar to Reddish et al. (2013), having shared intentionality seems to increase cohesion among members compared to focusing on one's own movements.

Intensity. Overall, the high intensity conditions had a statistically significant small positive effect on cohesion when compared to moderate and low conditions combined, M_{ES} = 0.18, *se* = 0.08, *p* = .026, *k* = 5, 95% CI [0.02, 0.34]. Performing high intensity movements increased cohesion among members compared to the other two intensity conditions. This is consistent with results by Prapavessis and Carron (1997) who found a positive association between intensity and cohesion among athletes.

Affect

Synchrony. Similar to the thesis's findings on cohesion, the positive affect results from this mini-meta-analysis can be directly compared to the positive affect results reported in Study 1's meta-analysis.

Replicating Study 1's meta-analysis results, the results of this overall mini meta-analysis revealed that synchrony had a statistically significant small positive effect on positive affect when compared to other conditions, M_{ES} = 0.21, *se* = 0.06, *p* = .001, *k* =

7, 95% CI [0.08, 0.33]. Breaking this down further, there was no support for a statistically significant difference between the synchrony and asynchrony conditions on positive affect, M_{ES} = 0.10, *se* = 0.09, *p* = .254, *k* = 4, 95% CI [-0.07, 0.27], replicating Study 1's results. Moreover, the results showed that participants in both the synchrony, M_{ES} = 0.33, *se* = 0.09, *p* < .001, *k* = 3, 95% CI [0.15, 0.51], and asynchrony conditions, M_{ES} = 0.31, *se* = 0.08, *p* < .001, *k* = 4, 95% CI [0.14, 0.47], reported statistically significantly higher positive affect compared to participants in the control condition.

Overall, there was no support for a statistically significant effect of synchrony on negative affect when compared to the other two conditions in combination, M_{ES} = -0.09, *se* = 0.06, *p* = .160, *k* = 7, 95% CI [-0.22, 0.04]. However, the individual comparisons between the conditions showed that when compared to the control conditions, synchrony statistically significantly decreased negative affect, M_{ES} = -0.20, *se* = 0.09, *p* = .034, *k* = 3, 95% CI [-0.38, -0.01], and asynchrony marginally decreased negative affect, M_{ES} = -0.16, *se* = 0.08, *p* = .061, *k* = 4, 95% CI [-0.32, 0.01]. There was no support for a statistically significant difference between the synchrony and asynchrony conditions on negative affect, M_{ES} = 0.01, *se* = 0.09, *p* = .944, *k* = 4, 95% CI [-0.17, 0.18].

These results indicate that performing actions together was sufficient to elicit increased positive affect and decreased negative affect among members. These results are consistent with Durkheim's collective effervescence hypothesis which will be discussed in the next section.

Shared intentionality. Overall, having a group goal of working together seemed to increase positive affect, M_{ES} = 0.01, *se* = 0.07, *p* = .890, *k* = 6, 95% CI [-0.12, 0.14], and negative affect, M_{ES} = 0.05, *se* = 0.07, *p* = .452, *k* = 6, 95% CI [-0.08, 0.19], when compared to having an individual goal, albeit the mean effect sizes were very small, and the effects were not statistically significant. Other studies have not found that shared intentionality affects mood. The studies in this thesis suggest that if there are effects, they are likely to be small and practically inconsequential.

Intensity. The results showed that the high intensity conditions had a marginally small positive effect on positive affect, M_{ES} = 0.15, *se* = 0.08, *p* = .063, *k* = 5, 95% CI [-0.01, 0.31], and a small negative effect on negative affect (although not statistically significant), M_{ES} = -0.08, *se* = 0.08, *p* = .341, *k* = 5, 95% CI [-0.24, 0.08], when

compared to moderate and low conditions combined. These results are consistent with Doyne et al. (1987) who showed that performing highly intense movements elicited more positive affect and less negative affect compared to performing movements at moderate or low intensity levels. Although exercise has consistently been shown to improve mood and well-being (Plante & Rodin, 1990; Yeung, 1996), the literature on physical intensity's effect on affective responses is less consistent. Hence, the results of this thesis offer further empirical support to the effects of highly intense physical activities on increased positive affect and decreased negative affect.

Summary

Taken together, I found that synchronous actions may impair divergent thinking. Furthermore, shared intentionality may enhance the generation of alternative solutions (although these solutions are less creative and novel), and may also impair convergent thinking. Additionally, performing actions in synchrony and asynchrony both increase cohesion and positive affect, which are further increased when shared intentionality is included. Finally, highly intense activities enhanced divergent and convergent thinking, as well as increased cohesion and positive affect among members.

Table 6.1

Mean Effect Sizes for the Overall Effects of Synchrony, Shared Intentionality, and Intensity, and the Comparisons on Each Outcome

Outcome	Manipulated variable	Comparison	*ES*	se_{ES}	*p*	*K*	-95% CI	+95% CI
Fluency	Synchrony	Overall (synchrony)	-0.12 †	0.06	.058	7	-0.25	0.00
		Synchrony vs. Asynchrony	-0.06	0.09	.468	4	-0.24	0.11
		Synchrony vs. Control	-0.19 *	0.09	.046	3	-0.37	-0.00
		Asynchrony vs. Control	-0.16 †	0.08	.059	4	-0.32	0.01
	Shared intentionality	Overall (group)	0.01	0.07	.914	6	-0.13	0.14
	Intensity	Overall (high)	0.20 *	0.08	.013	5	0.04	0.36
		High vs. Moderate	0.30 *	0.14	.030	2	0.03	0.56
		High vs. Low	0.15	0.10	.137	3	-0.05	0.35
		Moderate vs. Low	-0.03	0.14	.800	2	-0.30	0.23
Creativity	Synchrony	Overall (synchrony)	-0.03	0.06	.609	7	-0.16	0.09
		Synchrony vs. Asynchrony	-0.06	0.09	.532	4	-0.23	0.12
		Synchrony vs. Control	-0.01	0.09	.933	3	-0.19	0.17
		Asynchrony vs. Control	-0.09	0.08	.264	4	-0.26	0.07
	Shared intentionality	Overall (group)	-0.04	0.07	.535	6	-0.18	0.09
	Intensity	Overall (high)	0.14 †	0.08	.074	5	-0.01	0.30
		High vs. Moderate	0.10	0.14	.447	2	-0.16	0.37
		High vs. Low	0.17	0.10	.097	3	-0.03	0.36

		Moderate vs. Low	0.17	0.14	.199	2	-0.09	0.44
Novelty	Synchrony	Overall (synchrony)	-0.03	0.06	.627	7	-0.16	0.09
		Synchrony vs. Asynchrony	-0.04	0.09	.622	4	-0.22	0.13
		Synchrony vs. Control	-0.02	0.09	.853	3	-0.20	0.17
		Asynchrony vs. Control	-0.10	0.08	.232	4	-0.26	0.06
	Shared intentionality	Overall (group)	-0.03	0.07	.671	6	-0.16	0.11
	Intensity	Overall (high)	0.17 *	0.08	.034	5	0.01	0.33
		High vs. Moderate	0.11	0.14	.399	2	-0.15	0.38
		High vs. Low	0.20 *	0.10	.045	3	0.00	0.40
		Moderate vs. Low	0.18	0.14	.184	2	-0.09	0.45
Convergent thinking	Synchrony	Overall (synchrony)	0.01	0.08	.857	4	-0.14	0.16
		Synchrony vs. Asynchrony	0.03	0.11	.824	2	-0.20	0.25
		Synchrony vs. Control	0.00	0.10	.968	2	-0.20	0.21
		Asynchrony vs. Control	-0.01	0.10	.911	2	-0.21	0.19
	Shared intentionality	Overall (group)	-0.08	0.07	.220	6	-0.22	0.05
	Intensity	Overall (high)	0.19 †	0.10	.053	4	-0.00	0.37
		High vs. Moderate	0.17	0.14	.223	2	-0.10	0.43
		High vs. Low	0.21	0.14	.129	2	-0.06	0.47
		Moderate vs. Low	0.01	0.14	.928	2	-0.25	0.28
Cohesion	Synchrony	Overall (synchrony)	0.12 †	0.06	.055	7	-0.00	0.25

		Synchrony vs. Asynchrony	-0.01	0.09	.866	4	-0.19	0.16
		Synchrony vs. Control	0.28 **	0.09	.003	3	0.09	0.46
		Asynchrony vs. Control	0.29 **	0.08	.001	4	0.12	0.45
	Shared intentionality	Overall (group)	0.11	0.07	.108	6	-0.02	0.24
	Intensity	Overall (high)	0.18 *	0.08	.026	5	0.02	0.34
		High vs. Moderate	0.23	0.14	.095	2	-0.04	0.49
		High vs. Low	0.15	0.10	.124	3	-0.04	0.35
		Moderate vs. Low	-0.22	0.14	.103	2	-0.49	0.05
Positive affect	Synchrony	Overall (synchrony)	0.21 **	0.06	.001	7	0.08	0.33
		Synchrony vs. Asynchrony	0.10	0.09	.254	4	-0.07	0.27
		Synchrony vs. Control	0.33 ***	0.09	< .001	3	0.15	0.51
		Asynchrony vs. Control	0.31 ***	0.08	< .001	4	0.14	0.47
	Shared intentionality	Overall (group)	0.01	0.07	.890	6	-0.12	0.14
	Intensity	Overall (high)	0.15 †	0.08	.063	5	-0.01	0.31
		High vs. Moderate	0.13	0.14	.333	2	-0.14	0.40
		High vs. Low	0.16	0.10	.110	3	-0.04	0.36
		Moderate vs. Low	-0.11	0.14	.415	2	-0.38	0.16
Negative affect	Synchrony	Overall (synchrony)	-0.09	0.06	.160	7	-0.22	0.04
		Synchrony vs. Asynchrony	0.01	0.09	.944	4	-0.17	0.18
		Synchrony vs. Control	-0.20 *	0.09	.034	3	-0.38	-0.01

		Asynchrony vs. Control	-0.16 †	0.08	.061	4	-0.32	0.01
	Shared intentionality	Overall (group)	0.05	0.07	.452	6	-0.08	0.19
	Intensity	Overall (high)	-0.08	0.08	.341	5	-0.24	0.08
		High vs. Moderate	-0.17	0.14	.215	2	-0.44	0.10
		High vs. Low	-0.03	0.10	.787	3	-0.22	0.17
		Moderate vs. Low	0.05	0.14	.725	2	-0.22	0.31

* $p < .05$ ** $p < .01$ *** $p < .001$ † marginal effect

Note: The overall comparison for synchrony compared synchronous actions to asynchronous and control conditions combined, and the overall comparison for intensity compared high intensity actions to moderate and low intensity actions combined.

Potential Explanatory Mechanisms

Scholars have proposed several potential mechanisms as hypothesised explanations for synchrony's effects on mostly social and affective responses. As discussed in Chapter 1, Hobson and colleagues (2018) recently provided a framework for the psychological functions of rituals. They suggested that rituals have three main regulatory functions – the regulation of social connection, emotions, and performance of goal states. Each function was explained via bottom-up (i.e., derived from the physical features of rituals such as synchronous actions) or top-down processes (i.e., derived from the appraisal and interpretation of the physical features) involved in the rituals. This thesis examines one feature of ritualistic behaviours – synchronised action, which is a bottom-up process of rituals according to Hobson et al. (2018). Using two of the three regulatory functions of Hobson et al.'s (2018) framework which are relevant to this thesis as a guide, I will speculate about the key mechanisms that potentially explain synchrony's effects on cohesion (social connection regulation) and positive affect (emotional regulation). From this discussion, I will consider the potential mechanism by which synchronous actions affect creative thinking. It is important to note that the mechanisms discussed here are not mutually exclusive; quite the opposite, it is plausible that such mechanisms might be interdependent. However, for the purposes of explaining them, they will be discussed separately. Table 6.2 provides an overview of how I have organised the discussed mechanisms based on the outcome variable.

Table 6.2

Potential Mechanisms Explaining Synchrony's Effect on Cohesion, Positive Affect, and Creative Thinking

Outcome variables	Mechanisms	
	Psychological	Neurobiological
Cohesion (social connection)	Self-other blurring (mirroring) Shared attention	Endogenous opioid system
Affect (emotional)	Collective effervescence	Endocannabinoid Endogenous opioid system
Creative thinking	Shared mental states/ Conformity of thought	-

Cohesion

Synchronous physical actions may increase cohesion among group members through three mechanisms. For more clarity, I have split the mechanisms into psychological mechanisms (i.e., self-other blurring, and shared attention), and a neurobiological mechanism (i.e., endogenous opioid system).

Self-other blurring. Mirroring someone else's actions has been proposed to blur the distinction between the concept of the self and the concept of the other. In her shared circuits model, Hurley (2008) proposed that similar self-generated and other-generated actions have shared circuits, that is to say that they share common representational domains. Based on this model, Hove (2008) argued that synchrony also blurs the distinction between the self and the other. Coordinating actions with another requires the prediction of the other person's action. Moreover, synchronous actions which are matched in form and time also require the addition of temporal prediction of the other person's actions in order to stay in time. These action predictions and temporal predictions are typically used to distinguish self-generated actions from other-generated actions (Rennung & Göritz, 2016). In the case of frequency-locked synchrony, the actions are matched in form and time which renders distinguishing self-generated from other-generated actions even more difficult.

Take for instance two individuals waving their hands in synchrony. When person A waves her hand following a particular rhythm, the motor codes of her movements (in her brain) are copied to allow for the same hand-waving movements to occur repeatedly. When she sees her own hand waving, the external visual input signals, and repeated motor codes of her movements form associations. If congruent, the repeated motor codes predictively simulate internal visual inputs of the same movements creating an inner loop of internal input signals and motor outputs, thereby allowing her to wave her hands repeatedly in rhythm. When person A sees person B waving his hand the same way in the same rhythm, the external visual input of person B's hand-waving matches person A's internal visual input of her own hand-waving (due to the matching of actions and time), and thus the associations between the visual input and repeated motor codes remain congruent in person A's mind. Hence, there is no distinguishing between the self-generated and other-generated movements.

If the action of the self and the prediction of the other's action continuously match in form and time, the similar actions may indicate to the brain that the actions

may be internally-generated, and thus attributed to the self (Hove, 2008). This blurs the distinction between the self and the other person, and results in the other person's actions feeling like your own (Hurley, 2008). This self-other blurring in the mind results in more social perceptive feelings of similarity and identity fusion (Swann, Gómez, Seyle, Morales, & Huici, 2009), which elicits a sense of oneness with group members, and results in increased cohesion.

Shared attention. Macrae et al. (2008) first considered that performing synchronous actions would require shared social attention which could facilitate social connection (i.e., cohesion). They found that participants remembered the experimenter's face more often and recalled more words the experimenter said during the session when they performed synchronous actions with her compared to those who did not. Miles et al. (2010b) showed similar results reporting higher memory recall of self-relevant and other-relevant (i.e., experimenter-relevant) information after synchronised actions compared to control conditions. This suggests that synchronising with others shifts the focus of each member's attention to the synchronising group members, which causes more self-relevant and other/group-relevant information to be processed in an interdependent manner through shared attention. This shared social attention may be the enabling factor that allows group members to feel socially connected to each other, and thus more cohesive.

Therefore, shared social attention may mediate the link between synchrony and cohesion (Reddish et al., 2013). Reddish and colleagues (2013) examined a path analysis with the inclusion of shared intentionality which supported this hypothesis. Synchronous actions paired with shared intentionality (i.e., having a group goal of working together to perform movements) required participants to pay attention to each other in order to successfully synchronise their actions in time with each other. With each successful display of synchronised actions, group members receive a positive feedback loop of their successful performance (i.e., successfully synchronising movements in time with each other). This continued positive feedback loop which offers a consistent message of perceived synchrony and perceived cooperation, results in group members feeling more collaborative and cohesive.

Both the self-other blurring and shared attention mechanisms typically work best in dyadic interactions or interactions with very small groups. Self-other blurring, which requires the prediction of others' actions, is more difficult to achieve with more

participants, and shared intentionality becomes increasingly difficult as the number of participating members increase. Moreover, both mechanisms work best with frequency-locked synchronous actions. However, the results of this thesis showed that asynchronous actions also increased cohesion when compared to control conditions. It may be the case that a neurobiological mechanism could potentially explain both synchrony and asynchrony's effects on increased cohesion, and for larger groups of people.

Endogenous opioid system. Robin Dunbar and his colleagues (Dunbar, 2010; Dunbar, Kaskatis, MacDonald, & Barra, 2012b; Dunbar & Shultz, 2010; Machin & Dunbar, 2011) conjectured that music and dance for humans have the same social bonding functions as grooming for primates. Primates spend a lot of their time grooming as a form of social and affiliative behaviour, but this is not conducive for humans (especially in modern times) due to time constraints and the larger number of members we have in our groups. Hence, humans use other activities such as music and dance (both features of rituals), and laughter (Dunbar et al., 2012a), to facilitate social bonding. Just as grooming activities release endorphins in primates, so do music and dance in humans, which Dunbar suggested plays an important role in social bonding processes.

Endorphins are endogenous opioid neuropeptides produced in the central nervous system that function as neurotransmitters as well as neuromodulators by inducing a mild opiate-like 'high' which results in certain analgesic effects and feelings of well-being (Dunbar, 2010; Holden et al., 2005). Endorphins have been shown to play a role in the pain control system, as well as have an effect on mood and stress (Mueller et al., 2010; Zubieta et al., 2003). Specifically, endorphin release in the body increases pain tolerance and positive affect, and buffers against stress (see Bodnar, 2016, for a review of the effects of endogenous opioids).

Studies have shown that physical activity, especially activities with higher levels of physical intensity such as exercise, activates the endogenous system which releases endogenous opioids. By using blood pressure cuffs to induce ischemic pain, these studies have typically used pain tolerance as an assay for endorphin release in the

system (Boecker et al., 2008; Cohen et al., 2010)[6]. Studies by Cohen and colleagues (2010), and Sullivan and Rickers (2013) showed that rowing and running in groups respectively, increased participants' pain thresholds compared to when rowing and running alone. This effect of increased pain thresholds after performing activities together with others was also found to be independent of prior social bonds (Sullivan & Rickers, 2013).

More importantly, in two studies, Tarr and colleagues (Tarr et al., 2015; 2016) found that performing synchronous body movements increased pain tolerance and social bondedness. Additionally, body movements which were more physically intense also increased pain tolerance and feelings of social bonding. The authors suggested that synchronous actions that are also more physically intense encourage social bonding by activating the endogenous system. However, this mechanism by which synchrony increases cohesion through the release of endorphins has not been directly tested. This is a potential avenue for future research.

Although studies have found some evidence for synchrony increasing cohesion through the potential activation of the endogenous opioid system, this mechanism could also be used to explain the result that asynchronous actions increased cohesion as well. The studies on physical activity by Boecker et al. (2008), Cohen et al. (2010), and Sullivan and Rickers (2013) suggest that physical activities with higher intensity levels are sufficient to induce effects on the endogenous opioid system without the need for frequency-locked synchronous actions. Moreover, participants in those studies performed the physical activity together in groups of five and more. This indicates that the endogenous system may be suitable for inducing cohesion in larger groups.

Positive Affect

Similar to the mechanisms which explain synchrony's increase in cohesion, the mechanisms which explain synchrony's increase in positive affect can also be categorised into psychological and neurobiological mechanisms.

[6] The blood-brain barrier prevents brain endorphins to cross over, and so the only way to directly measure endorphin levels in the brain is through an invasive lumbar puncture (Boecker et al., 2008). Hence researchers typically use pain tolerance measurements as an assay for endorphin release because higher levels of endorphins are associated with elevated pain threshold.

Collective effervescence. Durkheim's (1912/1995) "collective effervescence" hypothesis has been used to explain why synchrony increases positive affect and decreases negative affect among group members. According to Hobson and colleagues (2018), one of the functions of rituals is to regulate emotions by reducing anxiety and negative emotions. With the use of physical action (in particular, sequences of rigid and repetitive actions), rituals can serve as a distraction from negative emotions such as anxiety. McNeill (1995), Ehrenreich (2006), and Haidt et al. (2008) conjectured that muscular bonding – activities in which people are moving together similarly (i.e., synchronised activities) such as rhythmic dancing, drumming, and singing which are typically performed in rituals – alter the emotions of participating group members by increasing positive emotions and decreasing negative emotions. When people are immersed in these collective activities, the collective "electricity" (or energy) and bond they form during the activity triggers feelings of happiness and well-being, thus reducing the state of negative emotions. Hobson and colleagues (2018) suggested that the endocannabinoid system and endogenous opioid system (see below) may also explain the effects of ritualised behaviours such as synchronous actions on affective responses.

Endocannabinoids and endogenous opioids. The endogenous system has also been implicated as playing a role in the positive effects of rituals (Hobson et al., 2018) and physical activity (Holden et al., 2005; Raichlen et al., 2013). It is suggested that the endocannabinoid system – our body's reward system – plays an important role in mediating physiological responses to more strenuous activities such as dancing and exercise (Dietrich & McDaniel, 2004; Dunbar et al., 2012; Sparling et al., 2003). For example, Sparling and colleagues (2013) found that participants had an increase in levels of anandamide (a chemical released from the endocannabinoid system) after running or cycling.

Endorphins which have been implicated in social bonding effects have also been found to induce feelings of euphoria and increased happiness – a phenomenon termed as the "runner's high" (Holden et al., 2005). Boecker and colleagues (2008) found changes in endogenous-associated brain regions after participants performed strenuous (i.e. more physically intense) physical activity. Participants also reported higher ratings of euphoria and happiness after the activity. Hence, the researchers suggested that the

increased feelings of happiness were attributed to the activation of the endogenous opioid system.

Both the endocannabinoid system and endogenous opioid system have been hypothesised to elicit a state of calmness and analgesia, as well as happiness, euphoria, and well-being after (strenuous) physical activity. Therefore, performing synchronised actions, especially at higher levels of intensity, is suggested to increase positive affect, and decrease negative affect.

The two mechanisms discussed (i.e., collective effervescence, and the endogenous systems) to explain synchrony's effects on positive affect can also explain the result that asynchronous actions also increased positive affect when compared to control conditions. They do not specify the need for frequency-locked synchronous actions. For both mechanisms, it seems that the performance of actions in groups is sufficient to induce affective responses.

Creative Thinking

Synchronous movements and vocalisations require shared attention from participating members of the group. As mentioned above in the shared attention mechanism, Macrae et al. (2008) and Miles et al. (2010b) found that synchronising with others led to higher recall of self-relevant and other-relevant (i.e., the synchronising person) information. In line with this, Baimel and colleagues (2015) conjectured that behavioural synchrony could foster theory of mind or mentalizing, which refers to the ability to reason about one's own mental state and reason about other people's mental states. Synchronising with another requires the ability to perceive and react to the other's actions (Prinz, 1997) which, according to Baimel and colleagues (2015), fosters shared mental states. Through shared attention, Baimel et al. (2015) suggested that synchronous actions engage cognitive systems that allow a person to prepare their mind for thinking about others' mental states. This diminishes the psychological distance between the person and the other, as well as reduces egocentric thoughts and tendencies.

Very recently, Baimel and colleagues (2018) tested this hypothesis empirically with three experiments. Adapting the experimental method of Wiltermuth and Heath (2009), participants were required to sing and move cups in synchrony, asynchrony, or not sing or move at all. After the movement manipulation, participants answered different tests that assessed mentalizing propensities (e.g., perspective taking/cognitive empathy – efficiency at predicting the mental state of another person), and mental state

reasoning (e.g., recognition accuracy of another person's emotion). Overall, their results showed support of synchrony's facilitation of theory of mind or mentalizing.

In a similar vein to Baimel and colleagues' (2018) hypothesis that synchrony could foster shared mental states, Dong and colleagues (2015) suggested that synchronous actions could also facilitate conformity. In a series of experiments, half the participants were required to perform simple exercise movements with each other, mainly either in synchrony or asynchrony. The other half of participants were required to observe the exercises being performed. The results showed that participants who performed the exercises in synchrony with each other exerted more conformity in their decision-making and judgements in subsequent unrelated tasks. However, observers who watched the performance exerted less conformity. Dong et al. (2015) argued that synchronising actions with someone, especially when they have a shared goal to do so (i.e., shared intentionality), requires attentional focus which encourages a similar copying-mindset (i.e., shared mental state), which increases conformity to others' behaviours.

Both the studies by Baimel et al. (2018) and Dong et al. (2015) showed that synchronous actions led to shared mental states, possibly from the shared attention required to perform the actions. Dong et al. suggested that the copying-mindset from performing synchronous actions restricts the focus and amount of attention available to attend to other stimuli, and hence restricts the freedom to assert individuality. In the same way, these shared mental states – or as Durkheim (1912/1995) termed it as conformity of thought – most likely stifle creativity and uniqueness, and hence inhibit the generation of divergent or alternative ideas (divergent thinking). This offers some explanation for why highly cohesive groups (i.e., synchrony has been shown to increase cohesion) have a tendency to conform to the group's normative decision – groupthink (Janis, 1982).

Summary

Based on the overall findings that both synchronous and asynchronous actions increased cohesion and positive affect, it is likely that these results can be explained by the collective effervescence and endogenous mechanisms. Victor Turner (1969)'s concept of *communitas* speaks to a similar idea, that people in a community share common experiences which connects the individuals in that community. This

connection induces positive feelings, as well as strong affiliative and social bonding effects.

Additionally, the results showed that highly intense physical activities elicited higher cohesion and positive affect among group members. From the mechanisms discussed above, only the endogenous system – both endogenous opioid and endocannabinoid – considered the intensity levels of a physical activity alongside the effects of synchronous actions. This provides further support to the important role that this system plays for the effects of synchrony, and rituals, on social and affective outcomes.

Finally, prior to this thesis, previous literature has not investigated the direct association between synchronous actions and creative thinking. Hence, the proposed mechanism for how synchrony could potentially impair divergent thinking was adapted from evidence of similar research studies. Nevertheless, it is highly likely that the shared attention mechanism is a fundamental mechanism that explains synchrony's effect on divergent thinking. Shared mental states which occur during the performance of synchronous actions may impair divergent thinking, as this thesis has shown overall.

Limitations

There were three limitations of the studies conducted in this thesis which need to be addressed. The first is in regard to the duration of the movement tasks. The results showed that synchrony impaired divergent thinking in the naturalistic field study, but the main effect of synchrony on divergent thinking in the experimental study was not statistically significant. It is plausible that the short duration of the movement task in the experimental paradigm was not sufficient to elicit stronger creative thinking effects. In addition, the results showed that physical intensity had a strong positive effect on divergent thinking and cohesion in the field study, but this effect was not replicated in the experimental paradigm. It is also plausible that the endogenous opioid and endocannabinoid systems require a longer duration of physical activity to elicit effects. One explanation for these inconsistencies could be due to the duration of the movement task. In the field study, participants performed physical movements for a duration which ranged from 50 minutes to 1.5 hours. In comparison, participants in the experimental studies only performed movements for five or six minutes, following similar experimental paradigms from previous studies (e.g. Reddish et al., 2013). This could

potentially explain why we did not find stronger effects. Therefore, future studies should consider extending the duration of the movement task to experimentally test the relevant thresholds. It will also provide for more ecological validity to more closely mimic what occurs in real-world contexts (e.g., music and dance performances in real-world contexts are often longer than five minutes). Most studies examining the effects of physical activity on the endogenous system have conducted the movement tasks for an average of 30 minutes (Boecker et al., 2008; Davis et al., 2015).

The second limitation is in regard to a confounding factor with the empirical studies. As the primary investigator of this thesis, I conducted all the studies. Hence, I was not blind to the research aims and hypotheses of each individual study. This may have provided a slight unconscious bias to certain conditions. In their meta-analysis, Rennung and Göritz (2016) found that the effect of synchrony on prosocial attitudes and prosocial behaviours were statistically significantly larger when the experimenter was not blind to the hypotheses compared to when the experimenter was blind. It is likely that being the experimenter in all the studies and being aware of the hypotheses could have implicitly reinforced responses from participants in certain conditions (such as more cohesion and positive affect) over others. This can potentially be controlled for in the study design of future studies in this area.

Finally, a third limitation is in regard to the potential social facilitation effect for the creative thinking measures. Participants who were given the group goal of performing movements with each other, whether in synchrony or asynchrony, generated less creative and novel responses in the divergent thinking measure, and had lower scores on the convergent thinking measure. It is likely that having to perform with each other induced co-action social facilitation effects on participants, which impaired their performances on these cognitively demanding tasks. Hence, future studies could take this into consideration to minimise the social facilitation effect as much as possible. Understandably however, it is difficult to minimise this effect if the experimental paradigm requires performing synchronised actions in groups. Perhaps the recent developments in virtual reality may offer some solutions. Recent studies by Jacques Launay and his colleagues (Launay et al., 2013; Launay, Dean, & Bailes, 2014) have shown that performing synchronous actions with a virtual partner increased trust and affiliation. Using this paradigm, it may be possible to induce synchrony effects by having participants perform synchronous actions with two or more virtual partners to potentially control for social facilitation effects.

Future Research Avenues

Here, I present two future research avenues by which the field of synchrony can be advanced in terms of its previously untested association with creative thinking. Now that this thesis has presented a direct association between synchronous actions and creative thinking, it is important to test the specific process mechanisms by which synchrony elicits effects on creative thinking. In the subsection explaining potential mechanisms, having shared mental states was suggested to be a potential mechanism by which synchronous actions impair divergent thinking. Baimel and colleagues (2018) showed that synchrony facilitated theory of mind or mentalizing, which the authors argued occurred through shared mental states between participating members. In addition, conformity in thought and action could potentially mediate the relationship between synchrony and creative thinking. Dong et al. (2015) found that synchronous actions fostered more conformity in participating members. Based on the evidence of groupthink behaviour (Janis, 1982; Landy & Conte, 2010; Larey & Paulus, 1999), it is highly likely that this behavioural conformity also leads to impaired divergent thinking. Perhaps a first step in examining if these mechanisms could play a role in synchrony's effects on creative thinking is to incorporate all these variables in a study. For example, a study could assess mentalizing and creative thinking after participants perform synchronous actions, or assess conformity and creative thinking after participants perform synchronous actions, in order to test if mentalizing and conformity mediate the relationship between synchrony and creative thinking. Testing these mechanisms more directly was beyond the scope of the current research programme. Nevertheless, an examination of this process mechanism will greatly benefit the understanding of how synchrony affects creative thinking.

Furthermore, it could be beneficial to synchrony and group dynamics research to investigate when during the evolution of a group is synchrony beneficial, and when is synchrony detrimental. Highly cohesive groups are more likely to engage in groupthink-based decisions compared to groups that are not cohesive (Janis, 1982). However, groups at the beginning or early stage of group formation are not yet highly cohesive, and are less likely to engage in groupthink. Hence, it could be the case that synchrony is beneficial in the early stages of group formation to increase social bonding perceptions (i.e., cohesion, affiliation, etc.) amongst new members of the group. Synchrony may also function to increase their focus and attention to their group members and

information which is shared amongst them (i.e., group-relevant information). On the other hand, synchrony may not be beneficial to well-established groups because synchrony may increase group cohesion and conformity of thought, and thereby increase the likelihood of groupthink. This potential future research avenue has practical implications especially in the workplace.

Practical Implications

The findings from this thesis have a wide range of practical implications across multiple institutions. In the education system, coordinated singing, dancing, and exercising have beneficial ramifications for promoting cooperative behaviour and social bonding amongst students, as well as increased well-being. These activities do not have to be in exact synchrony either, as the results of this thesis suggest that asynchronous activities also foster cohesion and positive affect. Encouraging participation and observation of these rhythmic activities could potentially also reduce out-group biases and negative prejudicial tendencies (Reddish et al., 2016). Furthermore, schools could encourage physical activities with higher intensity levels such as dance, exercise, and various sports activities because they could foster interconnectedness and team-bonding. However, careful thought should go into which activities are best for creativity. While highly intense activities may be beneficial to enhance both components of creative thinking, synchronous activities may be detrimental for divergent thinking.

Within the workplace, team-building activities (typically with synchronous actions) are a popular go-to method for promoting social cohesion and boosting morale amongst the employees. A real-world example of these activities is Walmart staff chanting the Walmart chant every morning before the start of their work day (Kluver et al., 2014). This may still be valuable for increasing cooperation, cohesion, trust, and well-being among the employees, and thereby improving performance. Nonetheless, I would argue that synchronous team-building activities may be detrimental for certain roles due to the finding that synchrony may impair divergent thinking. For example, synchronous activities may be useful for increasing performance in highly structured roles with rigid protocols (e.g., factory line jobs). However, synchronous activities may be ineffective and potentially detrimental for creative roles which require a lot of problem-solving and/or novel contribution of ideas and products (e.g., advertising,

creative arts). Hence, when developing team-building activities, it is crucial that the activity is tailored for the role, job type, and organisation with clear intentions as to the purpose it is meant to serve.

Concluding Remarks

Rituals are ubiquitous in our day-to-day lives and offer tacit evolutionary benefits to human societies. A key feature in ritualistic behaviours is synchronous actions. The synchrony literature has mostly focused on behavioural, social, and affective outcomes of synchronous actions, and very few cognitive processes have been examined. This thesis aimed to address this gap by investigating and providing novel theoretical and empirical insights into synchrony's effect on creative thinking as a cognitive outcome variable. In addition, the thesis aimed to synthesise the existing synchrony literature to examine synchrony's overall effects on the various outcome variables. Across four studies, I found that synchrony generally has a positive effect on prosocial behaviour, social bonding perceptions, and positive affect. Synchrony was found to potentially impair divergent thinking. Additionally, I found that another feature of ritualistic behaviours – physical intensity – increased cohesion and positive affect, and facilitated both aspects of creative thinking (i.e., divergent thinking and convergent thinking). Being the first series of studies to empirically examine the direct association of synchronous actions on creative thinking, more research needs to be conducted to further investigate the underlying mechanism(s) of this association. At present day, with our current global political climate tackling the issue of similarity and uniformity versus diversity and inclusion, this thesis bears important implications. Policies should be put in place to support rhythmic activities and exercises (which do not have to be in exact synchrony) for the behavioural, social, affective, and cognitive benefits of the community.

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Appendix A: Supplementary Material for Study 1

Table A.1

Study Characteristics and Corresponding Outcome Variables

Study	Author	Year	Publication Status	N	Behavior	Perception	Cognition	Affect
1	Anshel & Kipper	1988	Published	96	Cooperation	Trust		
2	Baimel (a), Exp 1	2015	Unpublished	116			Theory of mind	
3	Baimel (b), Exp 2			149		Social cohesion	Theory of mind	
4	Baimel (c), Exp 3			294		Social cohesion	Theory of mind	
5	Dam	2012	Unpublished	42	Cooperation	Entitativity, Trust, Interconnectedness, Group cohesion, Self-construal		Positive Affect, Negative Affect, Happiness, Satisfaction
6	Dong, Dai & Wyer (a), Exp 1	2015	Published	144		Social exclusion	Conformity, Perceptions of freedom	
7	Dong, Dai & Wyer (b), Exp 3			336		Closeness, Similarity	Conformity, Attention, Perceived restriction	
8	Dong, Dai & Wyer (c), Exp 4			92			Conformity	
9	Dong, Dai & Wyer (d), Exp 5			54			Conformity	

10	Fessler & Holbrook	2014	Published	96		Bonding, Closeness, Envisioned physical formidability		Positive emotion, Negative emotion
11	Hove & Risen (a), Exp 1	2009	Published	44		Affiliation		
12	Hove & Risen (b), Exp 2			161		Affiliation		
13	Hove & Risen (c), Exp 3			60		Affiliation		
14	Koudenburg (a), Study 2 in Chapter 5	2014	Unpublished	104		Personal value, Entitativity, Belonging, Identification		
15	Koudenburg (b), Study 3 in Chapter 5			60		Personal value, Entitativity, Belonging, Voice in group		
16	Koudenburg (c), Study 4 in Chapter 5			163		Personal value, Entitativity, Belonging, Identification	Creativity	
17	Koudenburg (d), Study 5 in Chapter 5			99		Personal & Others' value, Entitativity, Belonging, Identification		
18	Kurzban	2001	Published	55	Cooperation			
19	Lumsden, Miles & Macrae	2014	Published	132		Social connection, Affiliation		Happiness, Sadness, Anger, Self-esteem

20	Macrae, Duffy, Miles & Lawrence	2008	Published	40			Memory	
21	Miles, Griffiths, Richardson & Macrae	2010 a	Published	26		Rapport		Positive affect, Negative affect
22	Miles, Nind, Henderson & Macrae	2010 b	Published	36			Memory	
23	Mogan	2012	Unpublished	35	Cooperation	Entitativity, Trust, Interconnectedness, Group cohesion, Self-construal		Positive Affect, Negative Affect, Happiness, Satisfaction
24	Mote	2013	Unpublished	61	Cooperation	Entitativity, Trust, Interconnectedness, Group cohesion, Prosocial behavioral intentions		Positive Affect, Negative Affect, Happiness
25	Reddish, Bulbulia & Fischer (a), Exp 1	2014	Published	109	Prosociality	Self-construal, Social inclusion, Similarity		Mood
26	Reddish, Bulbulia & Fischer (b), Exp 2			65	Prosociality	Closeness, Attraction, Entitativity, Similarity, Perceived cooperation		Mood
27	Reddish, Fischer & Bulbulia (a), Exp 1	2013	Published	224	Cooperation	Entitativity, Similarity, Trust, Interdependent self-construal		

28	Reddish, Fischer & Bulbulia (b), Exp 2			27	Cooperation	Entitativity, Similarity, Trust, Interdependent self-construal, Perceived cooperation		
29	Reddish, Fischer & Bulbulia (c), Exp 3			164	Cooperation	Social unity, Trust	Attention	
30	Schachner	2015	Unpublished	60		Likeability, Same team, Trust, Similarity, Competence		Happiness
31	Schachner & Garvin (a), Exp 1	2010	Unpublished	27	Cooperation	Same team, Trust, Similarity		Happiness
32	Schachner & Garvin (b), Exp 2			55		Same team, Trust, Similarity	Conformity	Happiness
33	Sullivan, Gagnon, Gammage & Peters	2015	Published	26	Cooperation			
34	Tarr, Launay, Cohen & Dunbar	2015	Published	264		Perceived prosociality		Positive affect, Negative affect
35	Valdesolo & DeSteno	2011	Published	69	Cooperation	Similarity, Compassion		
36	Valdesolo, Ouyang, DeSteno	2010	Published	114		Similarity, Connectedness, Likeability	Perceptual sensitivity	

37	Wiltermuth, Exp 1	2012 a	Published	94		Emotional connection	Positive affect, Negative affect
38	Wiltermuth	2012 b	Published	104		Emotional connection	Positive emotion, Negative emotion
39	Wiltermuth & Heath (a), Exp 1	2009	Published	30	Cooperation	Interconnectedness, Trust	Happiness
40	Wiltermuth & Heath (b), Exp 2			144	Cooperation	Trust, Same team, Similarity	Happiness
41	Wiltermuth & Heath (c), Exp 3			157	Cooperation	Trust, Same team, Similarity	Happiness
42	Wood and colleagues	2014	Unpublished	99		Perceived prosociality	

Table A.2

Dependent Variables and Measures of the Dependent Variables by Study

Author(s)	Year	Outcome	Measure	Measure Author(s), Year	Description	Item(s), example(s) or instructions	No. of items	Scale	Scale points or Score on item
Anshel & Kipper	1988	Trust	Giffin-Trust Differential Questionnaire (subscales of Character & Dynamism)	Giffin (1968); Patton & Giffin (1974)	Measure trust toward either a group or an individual	Participants asked to evaluate a particular person according to their first, and general, impression of that individual by marking a number on the scale that separates each pair of adjectives. (p. 147)	18	7-point semantic differential bipolar adjectives	Higher rating of 5, 6 & 7 represent a more positive (trustful) assessment
					Character subscale – Reliability and intentions of the assessed individual	Information not provided	9	7-point semantic differential bipolar adjectives	Higher rating of 5, 6 & 7 represent a more positive (trustful) assessment
					Dynamism subscale – Degree of activity and openness of the assessed individual	Information not provided	9	7-point semantic differential bipolar adjectives	Higher rating of 5, 6 & 7 represent a more positive (trustful) assessment
		Cooperation	Prisoner's Dilemma game	Luce & Raiffa (1967);	Measure cooperation and	Participants asked to	30	Comparison between	If both chose blue = 3 points; If both

				Rappaport & Chammah (1965)	competitiveness among individuals	individually choose “red” or “blue” on 30 items. (p. 148)		participant's choice and partner's choice	chose red = 1 point; If one chose red and the other blue, red received 5 points and blue received 0
Baimel (a), Exp 1	2015	Theory of mind	Empathy Quotient (subscales of Cognitive Empathy, Affective Empathy & General Social Skills)	Baron-Cohen & Wheelwright (2004)	Capture individual differences in empathic tendencies	See subscales in the next 3 rows below	40	4-point Likert scale	Strongly disagree (1) to Strongly agree (4)
					Cognitive Empathy subscale (Perspective taking – One’s tendency towards and efficiency at predicting and engaging with mental states of others	E.g. “I am good at predicting how someone will feel.” (p. 22)	Information not provided	4-point Likert scale	Strongly disagree (1) to Strongly agree (4)
					Affective Empathy subscale – One’s tendency to emotionally react and engage with the mental states of others	E.g. “Seeing people cry doesn't really upset me.” (p. 22)	Information not provided	4-point Likert scale	Strongly disagree (1) to Strongly agree (4)

					General Social Skills subscale – Self-reported social skills	E.g. “I find it hard to know what to do in a social situation.” (p. 23)	Information not provided	4-point Likert scale	Strongly disagree (1) to Strongly agree (4)
Baimel (b), Exp 2	2015	Theory of mind	Empathy Quotient (subscales of Cognitive Empathy, Affective Empathy & General Social Skills)	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1	40	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1
		Social cohesion	Social Environment Questionnaire (3 independent measures of Relational Ties, Group Fusion & Group Identification)	See independent measures in the next 3 rows below	Assess individual perceptions of the group and participants' feelings towards them	See independent measures in the next 3 rows below	13	See independent measures in the next 3 rows below	See independent measures in the next 3 rows below
				Gomez, Brooks, Buhrmester, Vazquez, Jetten & Swann Jr (2011)	Relational Ties – Extent to which individuals felt they shared a connection with the other participants in their group	E.g. “Do you feel like you know any of the other participants very well?” (p. 29)	4	6-point Likert scale	Not at all (0) to Very much (5)
				Swann, Gomez, Conor, Francisco & Huici (2009)	Group Fusion – Extent to which the self felt close to, or 'fused' with that of the group	Participants asked to evaluate the extent to which they felt close to or	1	Pictorial scale	5 symmetrical degrees of overlapping circles between

						‘fused’ with the group. (p. 29)			‘Self’ and ‘Group’[a]
				Hogg, Sherman, Dierselhuis, Maitner & Moffitt (2007)	Group Identification – Extent to which individuals felt committed to the other participants in their group	E.g. “How much do you feel you belong to the group?” (p. 29)	8	9-point Likert scale	Not at all (1) to Very much (9)
Baimel (c), Exp 3	2015	Theory of mind	Empathy Quotient (subscales of Cognitive Empathy, Affective Empathy & General Social Skills)	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1	40	See measure in Baimel (a), Exp 1	See measure in Baimel (a), Exp 1
		Social cohesion	Social Environment Questionnaire (3 independent measures of Relational Ties, Group Fusion & Group Identification)	See independent measures in Baimel (b), Exp 2	See independent measures in Baimel (b), Exp 2	See independent measures in Baimel (b), Exp 2	13	See independent measures in Baimel (b), Exp 2	See independent measures in Baimel (b), Exp 2
		Theory of mind 2	‘Reading the Mind in the Eyes’ Test (subscales of Thinking & Feeling)	Baron-Cohen, Wheelwright, Hill, Raste & Plumb (2001)	Measure accuracy in emotional recognition - targets mental state attribution Thinking mental state subscale	Participants asked to correctly match mental states terms to pictures of eyes. (p. 34)	36	4 choices[a]	1 Correct answer, 3 Wrong answers[a]

					Feeling mental state subscale	E.g. "fantasizing; suspicious; reflective" E.g. "uneasy; worried; hostile" (p. 34)			
Dam	2012	Cooperation	Public Goods Game	Adapted from Wiltermuth & Heath (2009)	Indicator of behavioral cooperation	Participants given had NZD $5 to distribute between themselves and the group, and the money given to the collective pool would be doubled and distributed amongst the group, while the value of the money they kept would remain constant. (p. 9)	1	Participants could contribute some or all of NZD $5, in 50-cent increments (11 options altogether), to a group investment	Amount of money participants could choose to keep ranged from 0 to 5, increasing by 50 cents
		Entitativity	Multi-item measure	Adapted from Lickel, Hamilton, Wieczorkowska, Lewis, Sherman & Uhles (2000); Denson, Lickel, Curtis, Stenstrom & Ames (2006); Lakens (2010)	Measure perceptions of the group's cohesion	E.g. "How well do the values of the group reflect your own values?" (p. 10)	8	7-point Likert scale	Not at all (1) to Very much (7)

Trust	Multi-item measure	Adapted from Jarvenpaa, Knoll & Leidner (1998)	Measure level of trust towards other members of the group	E.g. “We have confidence in one another in this group.” (p. 10)	3	5-point Likert scale	Strongly disagree (1) to Strongly agree (5)
Interconnected-ness	Inclusion of Other in the Self (IOS) Scale	Aron, Aron & Smollan (1992)	Measure interconnectedness between the participants and the others in the group	Participants asked to select a picture that most closely resembles how they feel towards the other participants. (p. 11)	1	Pictorial scale	7 pictures of 2 overlapping circles labelled 'Self' and ‘Group' that are separated and gradually increase in overlap
Group Cohesion	Combined measure of Entitativity, Trust & Interconnectedness	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	12	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above
Self-construal	Six-fold Self-construal Scale (subscale of Others in this Group Activity)	Harb & Smith (2008)	Measure participants’ conception of themselves in relation to others	E.g. “I think of myself as connected (linked) to others in this group activity.” (p.11)	3	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)
Affect	Positive and Negative Affect Scale (PANAS)	Watson, Clark & Tellegen (1988)	Measure participants' current mood	“Thinking about how you feel right now, please indicate to what extent these feelings reflect you now…” (p. 10)	10	7-point Likert scale	Not at all (1) to Highly (7)
			Positive Affect	“Alert; Inspired; Determined;	5	7-point Likert scale	Not at all (1) to Highly (7)

						Attentive; Active" (p. 10)			
					Negative Affect	"Upset; Hostile; Ashamed; Nervous; Afraid" (p. 10)	5	7-point Likert scale	Not at all (1) to Highly (7)
					Happy	"Happy" (p. 10)	1	7-point Likert scale	Not at all (1) to Highly (7)
		Satisfaction	Adapted from the Satisfaction With Life Scale	Diener, Emmons, Larsen & Griffin (1985)	Measure global life satisfaction	"Please consider your current feeling towards yourself and your life…" : "How do you feel towards yourself currently?" (p. 10); "All things considered, how satisfied are you with your life as a whole these days?" (p. 11)	2	10-point Likert scale	Very negative (1) to Very positive (10); Completely unsatisfied (1) to Completely satisfied (10)
Dong, Dai & Wyer Jr. (a), Exp 1	2015	Conformity	Product preference questionnaire	Similar to Berger & Heath (2007)	Measure conformity to other's product choice	Participants asked to choose 1 of 3 brands in each of 5 different product categories (e.g., car navigation system, sunglasses, and sofa). Participants given the	5	3 choices	Lowest to Highest on market share (Higher number indicates greater tendency to copy others' preferences)

				proportion of persons who owned each product brand (e.g., sofa – participants told that according to an online consumer survey, 71% of other individuals owned a sofa from Wildon Home, 19% owned one from Skyline Furniture, and 10% owned one from Catnapper). (p. 64)			
Perceptions of freedom	Multi-item measure	Source unknown	Measure perceptions of actors' and observers' freedom	See independent measures in the next 2 rows below	3	5-point Likert scale	Not at all (1) to Very much (5)
			Actors' freedom	Participants asked to indicate the extent to which performing the exercises had made them feel that their freedom of behavior was restricted. (p. 64)	1	5-point Likert scale	Not at all (1) to Very much (5)

			Observer's freedom	Participants asked to indicate the extent to which performing the exercises restricted the actors' freedom, and the extent to which observing the exercise made them think about restrictions on their own freedom. (p. 64)	2	5-point Likert scale	Not at all (1) to Very much (5)
Social exclusion	Multi-item measure	Source unknown	Measure feelings of social exclusion and importance in experiment	See independent measures in the next 2 rows below	2	5-point Likert scale	Not at all (1) to Very much (5)
			Feeling of social exclusion	Participants asked to indicate the extent to which they felt socially excluded. (p. 64)	1	5-point Likert scale	Not at all (1) to Very much (5)
			Importance in experiment	Participants asked to indicate the extent to which they felt they were not an important part of the experiment. (p. 64)	1	5-point Likert scale	Not at all (1) to Very much (5)

Dong, Dai & Wyer Jr. (b), Exp 3	2015	Conformity	Product preference questionnaire	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	5	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1
		Attention	Single-item measure	Source unknown	Measure attention participants paid to others' behavior	"I paid attention to what others were doing." (p. 67)	1	7-point Likert scale	Disagree very much (1) to Agree very much (7)
		Perceived restriction	Single-item measure	Source unknown	Measure perceived restriction on participants' behavioral freedom	"Performing the exercise task made me feel that my behavior was being restricted." (p. 67)	1	7-point Likert scale	Disagree very much (1) to Agree very much (7)
		Closeness	Single-item measure	Source unknown	Measure closeness to other participants	"I felt personally close to other participants who were performing the exercises." (p. 67)	1	7-point Likert scale	Disagree very much (1) to Agree very much (7)
		Similarity	Single-item measure	Source unknown	Measure similarity to other participants	"I felt similar to other participants who were performing the exercises." (p. 67)	1	7-point Likert scale	Disagree very much (1) to Agree very much (7)
Dong, Dai & Wyer Jr. (c), Exp 4	2015	Conformity	Donation task	Similar to Levav & Zhu (2009)	Measure conformity to other's donation behavior	Participant given HK $10 that they could use for donating money to a list of 6 nonprofit organizations (3	1	6 choices	Participants' choice and amount noted (Conformity inferred from the difference between

						well known in Hong Kong, 3 less known). Participants told they could decide to give any amount they wished to each organization. If they donated less than $10 in total, they could keep the rest for themselves, and if they wanted to donate more, they could do so using their own money. (p. 69)			participants' donations to well-known charities and their donations to lesser known charities)
Dong, Dai & Wyer Jr. (d), Exp 5	2015	Conformity	Product preference questionnaire	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	5	See measure in Dong, Dai & Wyer Jr. (a), Exp 1	See measure in Dong, Dai & Wyer Jr. (a), Exp 1
Fessler & Holbrook	2014	Bonding	Combined measure of connectedness, likeability & similarity	Source unknown	Measure feelings of bonding with confederate	"How connected did you feel to the other participant?"; "How much did you like the other participant?"; "How similar did you feel to the other	3	7-point Likert scale	Not at all (1) to Very much (7)

				participant?" (p. 17)			
Closeness	Inclusion of Other in the Self (IOS) scale	Aron, Aron & Smollan (1992)	Measure feelings toward confederate	"Please circle the picture that best describes how you feel toward the other participant in today's study." (p. 18)	1	Pictorial scale	7 pairs of circles, labelled as 'self' and 'other', ranging from non-overlapping to almost entirely overlapping
Envisioned physical formidability	Composite measure of standardized values for estimated height, overall size & muscularity	Source unknown	Estimation of the bodily attributes of a supposed criminal based on a cropped "mugshot" of an angry male face	"What would you estimate this man's height to be, to the nearest half-inch?" (p. 14); "Circle the number of the image that best matches how you picture the man in the photo." (p. 15); "Circle the number if the image that best matches the strength of the man in the photo." (p. 16)	3	Open ended item 6-point scale 6-point scale	To the nearest half-inch; Assessed using an array of 6 silhouettes; Assessed using an array of 6 images of male bodies
Positive emotion	Multi-item measure	Source unknown	Measure current states of positive emotion	"Please rate how much you feel the following feelings or emotions, right now: Happy;	3	7-point Likert scale	Not at all (1) to Very much (7)

						Joyful; Elated" (p. 19)			
		Negative emotion	Multi-item measure	Source unknown	Measure current states of negative emotion	"Please rate how much you feel the following feelings or emotions, right now: Sad; Irritated; Angry" (p. 19)	3	7-point Likert scale	Not at all (1) to Very much (7)
Hove & Risen (a), Exp 1	2009	Affiliation	Single-item measure	Source unknown	Measure participants' affiliation with the experimenter	"How likable was the experimenter?" (p. 952)	1	9-point Likert scale	Extremely dislikable (1) to Extremely likable (9)
Hove & Risen (b), Exp 2	2009	Affiliation	Single-item measure	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1	1	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1
Hove & Risen (c), Exp 3	2009	Affiliation	Single item measure	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1	1	See measure in Hove & Risen (a), Exp 1	See measure in Hove & Risen (a), Exp 1
Koudenburg (a), Study 2 in Chapter 5	2014	Personal value	Multi-item measure	Koudenburg, Postmes, Gordijn & Van Mourik Broekman (2014)	Measure personal value to the group	"I had an important role in this group."; "I think I was indispensable to this group."; "Without me, this group would not function." (p. 107)	3	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)
		Entitativity	Entitativity Scale	Jans, Postmes & Van der Zee (2011)	Measure the extent to which participants perceive their	E.g. "I feel that the others and I are a unit." (p. 108)	4	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)

					group as a social unit				
		Belonging	Derived from the Need Threat Scale	Van Beest & Williams (2008)	Measure the extent to which group members feel that they belong to the group	E.g. “During the task I felt that I belonged with the others.” (p. 108)	4	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)
		Identification	Social Identification scale (subscales of Solidarity, Satisfaction & Homogeneity)	Leach et al. (2008)	Measure the extent to which group members identify with the group	E.g. “I feel a bond with this group.” (p. 108)	14	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)
Koudenburg (b), Study 3 in Chapter 5	2014	Personal value	Multi-item measure	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	3	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Entitativity	Entitativity Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Belonging	Derived from the Need Threat Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Voice in group	Multi-item measure	Source unknown	Measure the extent to which participants felt that they had a voice in the group	“I had the ability to make my own voice heard.”; “I dared to make my own voice heard.”; “I could be myself in the	5	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)

						group."; "I could be different than others in this group."; "I tried to make my own voice heard." (p. 116)			
Koudenburg (c), Study 4 in Chapter 5	2014	Personal value	Multi-item measure	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	3	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Entitativity	Entitativity Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Belonging	Derived from the Need Threat Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Identification	Social Identification scale (subscales of Solidarity, Satisfaction & Homogeneity)	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	14	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Creativity	Group creativity task	Source unknown	Measure the number of unique & original ideas generated by each group	Participants asked to write a promotion plan for a theater play of Romeo & Juliet. (p. 122)	1	5-point scale	Not original (1) to Very original (5)

Koudenburg (d), Study 5 in Chapter 5	2014	Personal value & Other's value	Multi-item measure	See measure in Koudenburg (a), Study 2 in Chapter 5	Measure personal value and other group members' value to the group	Same measures as in Koudenburg (a), Study 2 in Chapter 5 with 3 additional items : E.g. "I think the person on my right/left is indispensable to the group." (p. 128)	6	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Entitativity	Entitativity Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Belonging	Derived from the Need Threat Scale	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	4	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
		Identification	Social Identification scale (subscales of Solidarity, Satisfaction, Homogeneity & Self-stereotyping)	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5	Informat-ion not provided	See measure in Koudenburg (a), Study 2 in Chapter 5	See measure in Koudenburg (a), Study 2 in Chapter 5
Kurzban	2001	Cooperation	Public Goods game	Marwell & Ames (1979)	Measure cooperation among participants	Participants given 10 tokens which they could divide any way they chose	10 rounds	10 tokens per round (50cents per token)	Participants' allocation of tokens to the 2 accounts

						between 2 accounts, and that they would earn the full value of each token that they put in their Personal Account, as well as a fraction of the value for each token they and the other participants put in the Public Account (1/3 of the total number of tokens placed in this account). (p. 249)			
Lumsden, Miles & Macrae	2014	Mood	Mood analog scale	Source unknown	Measure participants' current mood	Participants asked to rate their mood (i.e., how happy/sad/angry they were currently feeling). (p. 4)	3	150mm Analog scale	Not at all to Very much
		Self-esteem	State Self-esteem Scale (subscales of Performance, Social & Appearance)	Heatherton & Polivy (1991)	Measure state self-esteem	Information not provided	20	Information not provided	Information not provided

		Social connection	Inclusion of Other in the Self (IOS) scale	Aron, Aron & Smollan (1992)	Measure participants' connection with the confederate	Participants asked to select which of 7 pairs of circles best depicts their relationship. (p. 4)	1	Pictorial scale	7 pairs of circles of increasing closeness
		Affiliation	Combined measure of how connected, likeable, close and similar participants felt to the confederate	Source unknown	Measure affiliation with the confederate	Participants rated on "How connected with them they felt."; "How likeable they were."; "How close they felt."; "How similar they were." (p. 4)	4	150mm Analog scale	Not at all to Very much
Macrae, Duffy, Miles & Lawrence	2008	Memory	Memory recall performance of a list of 20 words	Source unknown	Measure participants' memory	Participants asked to write down as many words as possible from earlier phase of the study. (p. 154)	20	Number of words recalled from previous phase of the study	Maximum of 20 words
Miles, Griffiths, Richardson & Macrae	2010a	Rapport	Shortened version of a standard rapport questionnaire	Bernieri, Davis, Rosenthal & Knee (1994)	Measure participants' rapport with confederate	Participants asked to indicate the degree to which each item described their expectations of the interaction on 5 positive and 5 negative aspects of rapport. (p. 54)	10	9-point Likert scale	Not at all (0) to Extremely (8)

			Positive Rapport aspects	"comfortable; friendly; harmonious; positive; satisfying" (p. 54)	5	9-point Likert scale	Not at all (0) to Extremely (8)
			Negative Rapport aspects	"awkward; boring; cold; dull; slow" (p. 54)	5	9-point Likert scale	Not at all (0) to Extremely (8)
Affect	Shortened version of the Positive and Negative Affect Scale (PANAS)	Watson, Clark & Tellegen (1988)	Measure participants' current mood	Participants asked to indicate the degree to which each item described the way they felt at that moment on 10 Positive affect & 10 Negative affect items. (p. 54)	20	9-point Likert scale	Not at all (0) to Extremely (8)
			Positive Affect	"determined; energetic; cheerful; sociable; motivated; enthusiastic; independent; attentive; alert; excited" (p. 54)	10	9-point Likert scale	Not at all (0) to Extremely (8)
			Negative Affect	"irritated; disgusted; hostile; lazy; tired; lonely; angry; downhearted;	10	9-point Likert scale	Not at all (0) to Extremely (8)

						alone; sad" (p. 54)			
Miles, Nind, Henderson & Macrae	2010b	General memory performance	Memory test	Source unknown	Measure participants' general memory	Participants asked to identify each item either as a word which they had spoken (total of 35 countries), a word that their partner had spoken (total of 35 countries), or a word that had not been spoken in the earlier stage (total of 70 countries). (p. 458)	140	3 options	Old-self word (word they had spoken); Old-other word (word their partner had spoken); New item (word that had not been spoken)
Mogan	2012	Cooperation	Public Goods Game	Adapted from Wiltermuth & Heath (2009)	Behavioral measure of cooperation	Participants given NZD $5 which they could either keep or distribute any portion to a public pool, and all the money that was put into the public pool was to be doubled and distributed evenly too all participants in that group.	1	Participants could keep or contribute to a public pool any portion of NZD $5, in 50-cent increments (11 options altogether)	Amount of money participants could choose to keep ranged from $0 to $5, increasing by 50 cents

				"Please circle how many tokens would you like to keep for yourself." (p. 10)			
Entitativity	Multi-item measure	Adapted from Lickel, Hamilton, Wieczorkowska, Lewis, Sherman & Uhles (2000); Denson, Lickel, Curtis, Stenstrom & Ames (2006); Lakens (2010)	Measure perceptions of group coherence	E.g. "People in this group are relatively uniform and similar to each other." (p. 11)	8	7-point Likert scale	Not at all (1) to Very much (7)
Trust	Multi-item measure	Adapted from Jarvenpaa, Knoll & Leidner (1998)	Measure trust among group members	E.g. "I can rely on people in this group." (p. 11)	3	5-point Likert scale	Strongly disagree (1) to Strongly agree (5)
Interconnected-ness	Inclusion of Other in the Self (IOS) scale	Aron, Aron & Smollan (1992)	Measure interconnectedness between the participants and others in the group	"Please circle the letter that best represents how close you currently feel to the group of people you have just taken part in this activity with." (p. 11)	1	Pictorial scale	7 pictures of 2 overlapping circles labelled 'Self' and 'Group' that are separated and gradually increase in overlap
Group Cohesion	Combined measure of Entitativity, Trust &	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	12	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above

	Interconnected-ness						
Self-construal	Six-fold Self-construal Scale (subscale of Others in this group activity)	Harb & Smith (2008)	Measure how people perceive their selves in terms of their relationships to other people	E.g. "I think of myself as connected (linked) to others in this group activity." (p. 12)	3	7-point Likert scale	Strongly disagree (1) to Strongly agree (7)
Affect	Positive and Negative Affect Scale (PANAS)	Watson, Clark & Tellegen (1988)	Measure participants' current mood	"Thinking about how you feel right now, please indicate to what extent these feelings reflect you now…" (p. 13)	10	7-point Likert scale	Not at all (1) to Highly (7)
			Positive Affect	"Alert; Inspired; Determined; Attentive; Active" (p. 13)	5	7-point Likert scale	Not at all (1) to Highly (7)
			Negative Affect	"Upset; Hostile; Ashamed; Nervous; Afraid" (p. 13)	5	7-point Likert scale	Not at all (1) to Highly (7)
			Happy	"Happy" (p. 13)	1	7-point Likert scale	Not at all (1) to Highly (7)
Satisfaction	Adapted from the Satisfaction with Life Scale	Diener, Emmons, Larsen & Griffin (1985)	Measure global life satisfaction	"Please consider your current feeling towards yourself and your life…" : "How do you feel towards yourself currently?" (p. 13);	2	10-point Likert scale	Very negative (1) to Very positive (10); Completely unsatisfied (1) to

						"All things considered, how satisfied are you with your life as a whole these days?" (p. 13)			Completely satisfied (10)
Mote	2013	Cooperation	Public Goods Game	Adapted from Wiltermuth & Heath (2009)	Behavioral measure of cooperation	Participants given NZD $5 of which they could contribute none, some or all (in 50 cent increments) to a group pot, and that all the money in the group pot would be doubled and divided equally among all group members. (p. 9)	1	Participants could keep or contribute to a public pot any portion of NZD $5, in 50-cent increments (11 options altogether)	Amount of money participants could choose to keep ranged from $0 to $5, increasing by 50 cents
		Entitativity	Multi-item measure	Adapted from Lickel, Hamilton, Wieczorkowska, Lewis, Sherman & Uhles (2000); Denson, Lickel, Curtis, Stenstrom & Ames (2006); Lakens (2010)	Measure perceptions of group entitativity	E.g. "People in this group share a common view on things in life." (p. 10)	6	7-point Likert scale	Not at all (1) to Very much (7)
		Trust	Multi-item measure	Adapted from Jarvenpaa, Knoll & Leidner (1998)	Measure trust among group members	E.g. "Overall, the people in my group are very	3	5-point Likert scale	Strongly disagree (1) to Strongly agree (5)

				trustworthy." (p. 10)			
Interconnected-ness	Inclusion of Other in the Self scale (IOS)	Aron, Aron & Smollan (1992)	Measure perceived level of interconnectedness between participants and the group	Participants asked to circle which option they thought best represented how they currently related to the group. (p. 10)	1	Pictorial scale	7 pictures of 2 overlapping circles labelled 'Self' and 'Group' that are separated and gradually increase in overlap
Group Cohesion	Combined measure of Entitativity, Trust & Interconnectedness	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	10	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above
Prosocial behavioral intentions	Prosocial Behavioral Intentions Scale	Bardi & Schwartz (2005)	Measure participants' prosocial behavioural intentions	Participants asked how likely they were to perform a behavior E.g. "Give small gifts to my friends and family for no reason." (p. 11)	30	5-point scale	Never (0) to All the time (4)
Affect	Positive and Negative Affect Scale (PANAS)	Watson, Clark & Tellegen (1988)	Measure participants' current mood	"Thinking about how you feel right now, please indicate to what extent these feelings reflect you now…" (p. 9)	11	7-point Likert scale	Not at all (1) to Highly (7)
			Positive Affect	"Alert; Inspired; Determined;	5	7-point Likert scale	Not at all (1) to Highly (7)

						Attentive; Active" (p. 9)		
					Negative Affect (with the addition of "embarrassed")	"Upset; Hostile; Ashamed; Nervous; Afraid; Embarrassed" (p. 9)	6	7-point Likert scale	Not at all (1) to Highly (7)
					Happy	"Happy" (p. 9)	1	7-point Likert scale	Not at all (1) to Highly (7)
Reddish, Bulbulia & Fischer (a), Exp 1	2014	Prosociality	Helping behavior	Source unknown	Measure willingness to help a PhD student by completing an unrewarded online questionnaire	Participants asked whether they would be willing to volunteer for an anonymous and unrewarded survey, which lasted for 20 or 40 minutes. (p. 5)	1	3 options	20 minutes; 40 minutes; Do not want to do the survey
		Mood	Mood Adjective Checklist (subscales of Hedonic tone, Tense arousal & Energetic arousal)	Matthews, Jones & Chamberlain (1990)	Measure participants' current mood[b]	Participants asked to rate how applicable adjectives were to their present mood.[b] (p. 46)	24[b]	4-point Likert scale[b]	Definitely not applicable (1) to Definitely applicable (4)[b]
		Self-construal	Six-fold Self-Construal Scale	Harb & Smith (2008)	Measure self-construal on personal, relational, collective self, and humanity levels[b]	"I think of myself as connected (linked) to my own self / family / friends / students at my university / the people I have	18[b]	7-point Likert scale[b]	To a very small extent (1) to (To a very large extent (7)[b]

				just done the activity with / humanity in general"; "I am aware of the needs, desires and goals of my own self / family / friends / students at my university / the people I have just done the activity with / humanity in general"; "I feel I have a strong relationship with my own self / family / friends / students at my university / the people I have just done the activity with / humanity in general"[b] (p. 45)			
Social inclusion	Adapted Inclusion of the Other in the Self (IOS) scale	Aron, Aron & Smollan (1992)	Measure closeness to other participants and closeness to other people in general	Participants asked to select the picture that best describes how close they currently felt to all the people they just did the activity with,	2	Pictorial scale	7 pictures of 2 circles labelled 'Self' and 'Other' with various degrees of overlap

						and how close they currently felt to the performance group.[b] (p. 45)			
		Perceived similarity	Adapted Homophily Scale	McCroskey, McCroskey & Richmond (2006)	Measure perceived similarity to the performance group[b]	E.g. "These people have thoughts and ideas that are similar to mine."[b] (p. 44)	15[b]	7-point Likert scale[b]	Strongly disagree (1) to Strongly agree (7)[b]
Reddish, Bulbulia & Fischer (b), Exp 2	2014	Out-group prosociality	Simplified version of the Group-level Game	Tajfel (2010)	Behavioral measure of generalized prosociality	Participants given NZD $15 each group and had the opportunity to divide between their own group and the other group, as they preferred. The total amount of money a participant's group received depended on the money that was allocated to their group from both in-group and out-group members. The total amount contributed to a members' group was then equally	1	Participants could divide any amount between their own group and the other group	Amount of money participants could choose to keep with their own group varied from NZD $0 to NZD $15

				divided between all group members. (p. 10)			
Closeness	Adapted Inclusion of the Other in the Self (IOS) scale	Aron, Aron & Smollan (1992); Schubert & Otten (2002); Swann, Gomez, Seyle, Morales & Huici (2009)	Measure felt closeness to one's own group and to the other group	Participants asked to select the picture that best describes how close they currently felt to fellow group members, and to members of the other group.[b] (p. 45)	1	Pictorial scale	7 pictures of 2 circles labelled 'Self' and 'Other' with various degrees of overlap
Attraction	Adapted multi-item measure	Bettencourt, Miller & Hume (1999); McCroskey, McCroskey & Richmond (2006)	Measure attraction to members of the in-group and out-group	Information not provided	8	7-point Likert scale[b]	Strongly disagree (1) to Strongly agree (7)[b]
			Attraction to people within one's own group	Information not provided	4	7-point Likert scale[b]	Strongly disagree (1) to Strongly agree (7)[b]
			Attraction to people within the other group	Information not provided	4	7-point Likert scale[b]	Strongly disagree (1) to Strongly agree (7)[b]
Perceived entitativity	Adapted multi-item measure	Lakens & Stel (2011); Wiltermuth & Heath (2009)	Measure perceived entitativity of the in-group	"How much did you experience a feeling of togetherness with the other participants?"; "How much did you feel you	4	7-point Likert scale[b]	Not at all (1) to Very much (7)[b]

				were on the same team with the other participants?"; "How much did you feel you and the other participants were a unit?"; "How much did you feel disconnected from the other participants?"[b] (p. 85)			
Perceived similarity	Single-item measure	Source unknown	Measure perceived similarity of group members	"How much did you feel similar to the other participants?" (p. 10)	1	7-point Likert scale[b]	Not at all (1) to Very much (7)[b]
Perceived cooperation	Single-item measure	Source unknown	Measure perceived cooperation among group members	"How much did you feel you and the other participants cooperated during the task?" (p. 10)	1	7-point Likert scale[b]	Not at all (1) to Very much (7)[b]
Mood	Mood Adjective Checklist (subscales of Hedonic tone, Tense arousal & Energetic arousal)	See measure in Reddish, Bulbulia & Fischer (a), Exp 1	See measure in Reddish, Bulbulia & Fischer (a), Exp 1	See measure in Reddish, Bulbulia & Fischer (a), Exp 1	24[b]	See measure in Reddish, Bulbulia & Fischer (a), Exp 1	See measure in Reddish, Bulbulia & Fischer (a), Exp 1

Reddish, Fischer & Bulbulia (a), Exp 1	2013	Cooperation	Public Goods Economic Game	Source unknown	Test of behavioral cooperation	Participants given NZD $5 for which they could contribute some or all of this to a group investment. All money in the group investment would then be doubled and divided equally among all members of the group. Participants were asked to indicate how much, if any, of their money they would like to contribute to the group investment. (p. 2)	1	Participants could contribute some of all of NZD 5 to a group investment in 50-cent increments (11 options altogether)	Amount of money participants could choose to contribute ranged from $0 to $5, increasing by 50 cents.
		Entitativity	Single-item measure	Wiltermuth & Heath (2009)	Measure the degree to which a collection of people are perceived as a group	"How much did you feel you were on the same team with the other participants?" (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Perceived similarity	Single-item measure	Wiltermuth & Heath (2009)	Measure perceived	"How similar do you think you are to the other	1	7-point Likert scale	Not at all (1) to Very much (7)

					similarity to group members	participants?" (p. 3)		
		Trust	Single-item measure	Wiltermuth & Heath (2009)	Measure trust pertaining to the economic game	"How much did you trust the other participants going into the group investment exercise?" (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Interdependent self-construal	Adapted Inclusion of the Other in the Self (IOS) scale	Aron, Aron & Smollan (1992)	Measure how participants' see themselves in relation to other group members[b]	"Rate how close you currently feel to all the people you just did the activities with." (p. 3)	1	Pictorial scale	Series of 7 pictures of increasingly inclusive circles
Reddish, Fischer & Bulbulia (b), Exp 2	2013	Cooperation	Stag Hunt - Risky Coordination game	Source unknown	Measure behavioral cooperation	Participants asked to select option X (returned a guaranteed reward of $7 NZD) or Y (returned a $10 if the other partners opted for Y but returned $0 if at least one other partners opted for X). (p. 5)	1	Binary choice	Option X or Option Y
		Entitativity	Multi-item measure	Adapted from Lakens & Stel (2011)	Measure the degree to which a collection of people are	"How much did you experience a feeling of togetherness with the other	4	7-point Likert scale	Not at all (1) to Very much (7)

			perceived as a group	participants?"; "How much did you feel you were on the same team with the other participants?"; "How much did you feel you and the other participants were a unit?"; "How much did you feel disconnected from the other participants?" (p. 6)			
Perceived similarity	Multi-item measure	Extended from Wiltermuth & Heath (2009)	Measure perceived similarity to group members	"How much did you feel similar to the other participants?"; "How much did you feel different to the other participants?" (p. 6)	2	7-point Likert scale	Not at all (1) to Very much (7)
Trust	Multi-item measure	Extended from Wiltermuth & Heath (2009)	Measure trust pertaining to the economic game	"How much did you trust the other participants going into the payment choice game?"; "How confident were	2	7-point Likert scale	Not at all (1) to Very much (7)

					you that the other group members would choose option Y (the $10 or $0 option)?" (p. 6)			
		Interdependent self-construal	Adapted Inclusion of the Other in the Self (IOS) scale	Adapted from Aron, Aron & Smollan (1992); Modified from Schubert & Otten, 2002); Swann, Gomez, Seyle, Morales & Huici (2009)	Measure how participants' see themselves in relation to other group members[b]	"Rate how close you currently feel to all the people you just did the activities with." (p. 6)	1	Pictorial scale	Series of 7 pictures of increasingly inclusive circles with beginning of the scale extended with two further diagrams where the circles were separated at different distances and with the amount of circle that overlapped following the scale developed by Swann et al. (2009)
		Perceived cooperation	Single-item measure	Source unknown	Measure perceived cooperation among group members	"How much did you feel you and the other participants cooperated during the task?" (p. 6)	1	7-point Likert scale	Not at all (1) to Very much (7)
Reddish, Fischer & Bulbulia (c), Exp 3	2013	Cooperation	Stag Hunt - Risky Coordination game	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	1	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2

Entitativity	Multi-item measure	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	4	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2
Perceived similarity	Multi-item measure	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2
Interdependent self-construal	Adapted Inclusion of the Other in the Self (IOS) scale	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	1	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2
Social unity	Combined measure of Entitativity, Similarity & Interdependent self-construal	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above	7	See independent measures in the previous 3 rows above	See independent measures in the previous 3 rows above
Trust	Multi-item measure	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2	See measure in Reddish, Fischer & Bulbulia (b), Exp 2
Attention to other participants	Multi-item measure	Source unknown	Measure the amount of attention paid to the other participants	"How much did you pay attention to the other participants?"; "How much did you find the other participants aided in doing	4	7-point Likert scale	Not at all (1) to Very much (7)

						the activity?"; "How much did you try to ignore the other participants?"; "How much did you find the other participants distracting?" (p. 9)			
Schachner	2015	Likeability	Single-item measure	Source unknown	Measure liking of the confederate	Participants asked how much they liked the confederate. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Same team	Single-item measure	Source unknown	Measure feeling of being on the same team as the confederate	Participants asked how much they felt they were on the same team as the confederate. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Trust	Single-item measure	Source unknown	Measure trust of the confederate	Participants asked how much they trusted the confederate. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Similarity	Single-item measure	Source unknown	Measure similarity to the confederate	Participants asked how similar they were to the confederate. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)

		Competence	Single-item measure	Source unknown	Measure competence of the confederate	Participants asked how competent they thought the confederate was. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Happiness	Single-item measure	Source unknown	Measure participants' happiness	Participants asked how happy they were. (p. 7)	1	7-point Likert scale	Not at all (1) to Very much (7)
Schachner & Garvin (a), Exp 1	2010	Cooperation	Public Goods Game	Modeled after Wiltermuth & Heath (2009)	Measure behavioral cooperation[c]	Participants given 10 tokens and had to divide them between 2 accounts: public account (each token anyone puts in earns 25cents for every player), and a private account (each token put in earns 50cents for that player, 0 for other players). (p. 1)	5 rounds	Participants could allocate as many tokens as they wanted into either the public and private accounts	Tokens contributed to the public account out of 10 tokens
		Same team	Single-item measure	Modeled after Wiltermuth & Heath (2009)	Measure feelings of being on the same team with the other participants[c]	"How much did you feel you were on the same team with the other participants?"[c] (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)

		Trust	Single-item measure	Modeled after Wiltermuth & Heath (2009)	Measure participants' trust toward the other participants[c]	"How much did you trust the other participants going into the exercise?"[c] (p. 2)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Similarity	Single-item measure	Modeled after Wiltermuth & Heath (2009)	Measure participants' similarity to the other participants[c]	"How similar are you to the other participants?"[c] (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Happiness	Single-item measure	Modeled after Wiltermuth & Heath (2009)	Measure participants' current state of happiness[c]	"How happy are you right now?"[c] (p. 2)	1	7-point Likert scale	Not at all (1) to Very much (7)
Schachner & Garvin (b), Exp 2	2010	Conformity	Multi-item measure	Modeled after Epley & Gilovich (1999)	Measure conformity to confederates' answers	Participants asked for feedback about the experience by answering 2 questions: "How enjoyable was the experiment, on a 0-10 scale?"; "How interesting was the experiment, on a 0-10 scale?" One by one, 3 confederates answer first (either lower answers or 1,2,3 or high answers of 7,8,9), then	2	Distance between participants' answer and average of confederates' answer	Lower score (distance) denotes more conformity (out of 11)

						participant answers. (p. 1)			
		Same team	Single-item measure	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1
		Trust	Single-item measure	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1
		Similarity	Single-item measure	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1
		Happiness	Single-item measure	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1	1	See measure in Schachner & Garvin (a), Exp 1	See measure in Schachner & Garvin (a), Exp 1
Sullivan, Gagnon, Gammage & Peters	2015	Cooperation	Cooperative game	Wiltermuth & Heath (2009)	Measure behavioral cooperation	Participants given 10 tokens per round, and for each round they could contribute as many tokens as they wished to a public account or keep them in a private account. Tokens in the public account earned $0.15 to each person in the group; tokens in the private	5 rounds	Participants could contribute as many tokens as they wished to a public account or a private account	Number of tokens donated to the public account in each round (10 tokens in total)

						account earned $0.30 to only that member, but nothing to the other 2 members. (p. 654)			
Tarr, Launay, Cohen & Dunbar	2015	Perceived prosociality	Combined measure of an adapted version of the Inclusion of Other in Self (IOS) scale, Connectedness, Trust, Likeability & Similarity in Personality	Aron, Aron & Smollan (1992); Wiltermuth & Heath (2009); Wiltermuth & Heath (2009); Wiltermuth & Heath (2009); Valdesolo & DeSteno (2011); Valdesolo & DeSteno (2011)	Measure closeness towards the other participants in the testing group ('in-group') and their school class ('out-group')	"Thinking about all the pupils in this room now…" / "Thinking about all the pupils in the whole class…" : "… please choose the picture that best describes your relationship now." (p. 1) "… how much do you trust the other pupils?" (p. 1) "… how connected do you feel to the other pupils?" (p. 1) "… how likeable are the other pupils?" (p. 1) "… how much do you like the	6	Pictorial scale 7-point Likert scale	Labelled circles of increasing overlap to indicate relationship between 'self' and 'group' Very slightly or not at all (1) to Extremely (7)

						other pupils overall?" (p. 1) "… do you feel similar in personality to the other pupils?" (p. 1)			
		Mood	Positive and Negative Affect Scale (short form)	Mackinnon, Jorm, Christensen, Korten, Jacomb & Rodgers (1999)	Measure participants' current mood	"Please indicate how you are feeling in this moment: distressed; excited; upset; scared; enthusiastic; alert; inspired; nervous; determined; afraid" (p. 1)	10	7-point Likert scale	Very slightly or not at all (1) to Extremely (7)
Valdesolo & DeSteno	2011	Cooperation	Helping a "victim" task	Batson (1998) cf.	Measure altruism	Participants told they could assist another participant to complete a long and arduous task. If participants wanted to help, they were told that they could do math and logic problems (the task) for as much time as they had. (p. 264)	1	Participants' choice to assist the other participant in the task or not	Duration of time participant helped to complete the task

		Perceived similarity and liking	Combined measure of Similarity & Liking	Source unknown	Measure participants' perceived similarity in personality and liking of each other	"To what extent do you feel similar in personality to the participant with whom you completed the rhythmic ability task?"; Participants asked to indicate how much they liked the other participant. (p. 263)	2	7-point Likert scale	Not at all similar (1) to Extremely similar (7) Not at all (1) to Very much (7)
		Compassion	Multi-item measure	Source unknown	Assess participants' feelings regarding the situation of the victim who had to complete the red task (math and logic problems).	"Sympathy for victim"; "Pity for victim"; "Compassion for victim" (p. 264)	3	7-point Likert scale	Information not provided
Valdesolo, Ouyang, DeSteno	2010	Perceptual Sensitivity	Perceptual sensitivity task	Source unknown	Measure participants' perceptual sensitivity to the motion of other entities	Determine on each trial whether the blue ball continued at its pace while obscured behind the rectangle or if it briefly paused, causing a delay for its appearance at	21 random trials (delays range from 0s to 6s)	Binary choice	Yes (delay) or No (no delay)

						the other end. (p. 694)			
		Perceived similarity	Information not provided	Source unknown	Measure similarity to the partner	Information not provided	Information not provided	7-point Likert scale	Information not provided
		Connectedness	Information not provided	Source unknown	Measure connectedness with the partner	Information not provided	Information not provided	7-point Likert scale	Information not provided
		Likeability	Information not provided	Source unknown	Measure liking towards the partner	Information not provided	Information not provided	7-point Likert scale	Information not provided
Wiltermuth	2012a	Emotional connection	Combined measure of Connectedness, Closeness, Liking, Similarity, Self-other overlap	Source unknown	Measure participants' emotional connection to the experimenter	Participants asked how connected they felt to the experimenter; How close they felt to the experimenter; How much they liked the experimenter; How similar they felt to the experimenter. (p. 81)	5	7-point Likert scale	Not at all (1) to Very much (7)
				Aron, Aron & Smollan (1992)		Participants asked to select which of 7 pairs of circles best depicts their relationship to the experimenter.[a] (p. 597)		Pictorial scale	7 pairs of circles of increasing overlap[a]

		Positive affect	Multi-item measure	Source unknown	Measure participants' positive affect	Participants asked to indicate how "Happy; Joyful; Elated" they were. (p. 81)	3	7-point Likert scale	Not at all (1) to Very much (7)
		Negative affect	Multi-item measure	Source unknown	Measure participants' negative affect	Participants asked to indicate how "Sad; Angry; Irritated" they were. (p. 81)	3	7-point Likert scale	Not at all (1) to Very much (7)
Wiltermuth	2012b	Emotional connection	Combined measure of Closeness, Connectedness, Liking, Similarity, Self-other overlap	Source unknown	Measure participants' emotional connection to the experimenter	Participants asked how close they felt to the experimenter; How connected they felt to the experimenter; How much they liked the experimenter; How similar they felt to the experimenter. (p. 454)	5	7-point Likert scale	Not at all (1) to Very much (7)
				Aron, Aron & Smollan (1992)		Participants asked to select which of 7 pairs of circles best depicts their relationship to the experimenter.[a] (p. 597)		Pictorial scale	7 pairs of circles of increasing overlap[a]

		Positive emotion	Multi-item measure	Source unknown	Measure participants' positive affect	Participants asked to indicate how "Happy; Joyful; Elated" they were. (p. 454)	3	7-point Likert scale	Not at all (1) to Very much (7)
		Negative emotion	Multi-item measure	Source unknown	Measure participants' negative affect	Participants asked to indicate how "Sad; Angry; Irritated" they were. (p. 454)	3	7-point Likert scale	Not at all (1) to Very much (7)
Wiltermuth & Heath (a), Exp 1	2009	Cooperation	Weak Link Coordination Exercise	Weber, Camerer & Knez (2004); Weber, Rottenstreich, Camerer & Knez (2001)	Models situations in which group productivity is a function of the lowest level of input	Participants given a payoff grid and asked to choose a number from 1 to 7 without communicating (payoffs increase as a function of the smallest number chosen and decrease with the distance between the participant's choice of number and the smallest number chosen in the group). (p. 2)	6 rounds	Participants could choose a number from 1 to 7 based on the payoff grid	Participants' choice from 1 to 7
		Interconnected-ness	Single-item measure	Source unknown	Measure participants' connectedness to	"How connected did you feel with the other participants	1	7-point Likert scale	Not at all (1) to Very much (7)

					the other participants	during the walk?" (p. 2)			
		Trust	Single-item measure	Source unknown	Measure participants' trust toward the other participants	"How much did you trust the other participants going into the exercise?" (p. 2)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Happy	Single-item measure	Source unknown	Measure participants' current state of happiness	"How happy do you feel?" (p. 2)	1	7-point Likert scale	Not at all (1) to Very much (7)
Wiltermuth & Heath (b), Exp 2	2009	Cooperation	Weak Link Coordination Exercise	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	6 rounds	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1
		Trust	Single-item measure	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1
		Same team	Single-item measure	Source unknown	Measure feeling of being on the same team with the other participants	"How much did you feel you were on the same team with the other participants?" (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Similarity	Single-item measure	Source unknown	Measure participants' similarity to the other participants	"How similar are you to the other participants?" (p. 3)	1	7-point Likert scale	Not at all (1) to Very much (7)
		Happy	Single-item measure	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	1	See measure in Wiltermuth	See measure in Wiltermuth & Heath (a), Exp 1

								& Heath (a), Exp 1	
Wiltermuth & Heath (c), Exp 3	2009	Cooperation	Public Goods Game	Croson & Marks (2000)	Measure behavioral cooperation	Participants given 10 tokens per round that they could contribute into a public account or keep in a private account. Tokens in public account earned $0.25 for every member of the group; tokens in the private account earned $0.50 to the person holding the token but nothing to the other 2 group members. (p. 4)	5 rounds	Participants could contribute as many tokens as they wanted into either the public and private accounts	Tokens contributed to the public account out of 10 tokens
		Trust	Single-item measure	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1
		Same team	Single-item measure	See measure in Wiltermuth & Heath (b), Exp 2	See measure in Wiltermuth & Heath (b), Exp 2	See measure in Wiltermuth & Heath (b), Exp 2	1	See measure in Wiltermuth & Heath (b), Exp 2	See measure in Wiltermuth & Heath (b), Exp 2
		Similarity	Single-item measure	See measure in Wiltermuth & Heath (b), Exp 2	See measure in Wiltermuth & Heath (b), Exp 2	See measure in Wiltermuth & Heath (b), Exp 2	1	See measure in Wiltermuth	See measure in Wiltermuth & Heath (b), Exp 2

								& Heath (b), Exp 2	
		Happy	Single-item measure	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1	1	See measure in Wiltermuth & Heath (a), Exp 1	See measure in Wiltermuth & Heath (a), Exp 1
Wood, Caldwell-Harris, Back, Fanty, Ruggiero, Worsham & Boone	2014	Perceived prosociality	"Other Social" scale	Source unknown	Gauge of participants' willingness to offer assistance to or socially approach members of the opposite group (a measure of how prosocial losers would hypothetically be toward winners, and vice-versa)	"Imagine that one of the losers/winners realizes that she forgot her wallet, but has to go to work in downtown Boston. Would you give her enough money to get onto the T?; You have class with one of the losers/winners. He did not have enough time to eat before class and will not be able to until dinner, but you have an extra snack with you. Do you offer it to him?"; One of the members of the losers'/winners'	6	Binary choice	Yes or No

		group is in another one of your classes and she mentions how she missed class yesterday. Would you volunteer your notes to her?"; If you ran into a member of the losers'/winners' group at a party, would you say hello?"; If you got on a bus, and saw that the last empty seat was next to a member of the losers'/winners' group, would you sit down next to him or her?"; In the same situation, would you let a member of the losers'/winners' group sit next to you?" (p. 4)

Note: Exact wordings of items or instructions are denoted in quotation marks (i.e., "…").

[a] Information retrieved from the measure's original source.
[b] Information retrieved from the first author's doctoral thesis.
[c] The study was a replication of Wiltermuth & Heath (2009).

A.3) R code for meta-analysis

```
setwd("C:/Users/Reneeta/Dropbox/PhD/Studies/Meta-Analysis")
MA = read.csv("SynchronyMeta-analysisRawDatafilecsv.csv", header = TRUE)
str(MA)


# packages
        library (robumeta)
        library (dplyr)
        library (metafor)


# creating different data frames for each DV - Behaviour, Perception, Cognition, Affect

MA.beh<-MA%>%
  select(Authors,Year,Sync_Coor,GrpSizeMean,Behaviour.R,N,weight)%>%
  filter(!is.na(Behaviour.R))

MA.per<-MA%>%
  select(Authors,Year,Sync_Coor,GrpSizeMean,Perception.R,N,weight)%>%
  filter(!is.na(Perception.R))

MA.cog<-MA%>%
  select(Authors,Year,Sync_Coor,GrpSizeMean,Cognition.R,N,weight)%>%
  filter(!is.na(Cognition.R))

MA.aff<-MA%>%
  select(Authors,Year,Sync_Coor,GrpSizeMean,Affect.R,N,weight)%>%
  filter(!is.na(Affect.R))


# creating Fisher's z scores for each DV

MA.beh.Z <- escalc(measure="ZCOR", ri=Behaviour.R, ni=N, data=MA.beh,
slab=paste(Authors,Year,Sync_Coor,GrpSizeMean))

MA.per.Z <- escalc(measure="ZCOR", ri=Perception.R, ni=N, data=MA.per,
slab=paste(Authors,Year,Sync_Coor,GrpSizeMean))

MA.cog.Z <- escalc(measure="ZCOR", ri=Cognition.R, ni=N, data=MA.cog,
slab=paste(Authors,Year,Sync_Coor,GrpSizeMean))

MA.aff.Z <- escalc(measure="ZCOR", ri=Affect.R, ni=N, data=MA.aff,
slab=paste(Authors,Year,Sync_Coor,GrpSizeMean))
```

```
# overall effect analyses: REML (random effects maximum likelihood model),
Publication bias (Egger's regression test), and Forest plots

## BEHAVIOUR

### REML
res.beh <- rma(yi, vi, data=MA.beh.Z)
res.beh
confint(res.beh)

### Publication bias
regtest(res.beh)

### Forest plot
testvec <- c(0.274)
forest(res.beh, xlim=c(-1.6,1.6), atransf=transf.ztor,
      at=transf.rtoz(c(-.4,-.2,0,.2,.4,.6)), digits=c(2,1), cex=.7)
addpoly(x=testvec, ci.lb=0.139, ci.ub=0.398, atransf=transf.ztor, col="white", rows=-2,
cex=.7, mlab = "95% prediction interval")
text(-1.6, 26, "Author(s),Year", pos=4, cex=.7)
text( 1.6, 26, "Correlation [95% CI]", pos=2, cex=.7)


## PERCEPTION

### REML
res.per <- rma(yi, vi, data=MA.per.Z)
res.per
confint(res.per)

### Publication bias
regtest(res.per)

### Forest plot
testvec <- c(0.173)
forest(res.per, xlim=c(-1.6,1.6), atransf=transf.ztor,
      at=transf.rtoz(c(-.4,-.2,0,.2,.4,.6)), digits=c(2,1), cex=.7)
addpoly(x=testvec, ci.lb=-0.113, ci.ub=0.432, atransf=transf.ztor, col="white", rows=-2,
cex=.7, mlab = "95% prediction interval")
text(-1.6, 56, "Author(s),Year", pos=4, cex=.7)
text( 1.6, 56, "Correlation [95% CI]", pos=2, cex=.7)
```

```
## COGNITION

### REML
res.cog <- rma(yi, vi, data=MA.cog.Z)
res.cog
confint(res.cog)

### Publication bias
regtest(res.cog)

### Forest plot
testvec <- c(0.170)
forest(res.cog, xlim=c(-1.6,1.6), atransf=transf.ztor,
     at=transf.rtoz(c(-.4,-.2,0,.2,.4,.6)), digits=c(2,1), cex=.6)
addpoly(x=testvec, ci.lb=-0.197, ci.ub=0.495, atransf=transf.ztor, col="white", rows=-2,
cex=.6, mlab = "95% prediction interval")
text(-1.6, 27, "Author(s),Year", pos=4, cex=.6)
text( 1.6, 27, "Correlation [95% CI]", pos=2, cex=.6)


## AFFECT

### REML
res.aff <- rma(yi, vi, data=MA.aff.Z)
res.aff
confint(res.aff)

### Publication bias tests - Egger's regression test
regtest(res.aff)

### Forest plot
testvec <- c(0.111)
forest(res.aff, xlim=c(-1.6,1.6), atransf=transf.ztor,
     at=transf.rtoz(c(-.4,-.2,0,.2,.4,.6)), digits=c(2,1), cex=.6)
addpoly(x=testvec, ci.lb=-0.181, ci.ub=0.385, atransf=transf.ztor, col="white", rows=-2,
cex=.6, mlab = "95% prediction interval")
text(-1.6, 26, "Author(s),Year", pos=4, cex=.6)
text( 1.6, 26, "Correlation [95% CI]", pos=2, cex=.6)
```

```
# synchrony vs no action (control), and synchrony vs coordination analyses

## BEHAVIOUR

### specifying variables
MA.beh.Z$sync.contol <- ifelse(MA.beh.Z$Sync_Coor == "Sync - Control", 1, 0)
MA.beh.Z$sync.coor <- ifelse(MA.beh.Z$Sync_Coor == "Sync - Coordination", 1, 0)

### REML
Beh.SC <- rma(yi, vi, mods = ~factor(Sync_Coor) - 1, data = MA.beh.Z)
Beh.SC


## PERCEPTION

### specifying variables
MA.per.Z$sync.contol <- ifelse(MA.per.Z$Sync_Coor == "Sync - Control", 1, 0)
MA.per.Z$sync.coor <- ifelse(MA.per.Z$Sync_Coor == "Sync - Coordination", 1, 0)

### REML
Per.SC <- rma(yi, vi, mods = ~factor(Sync_Coor) - 1, data = MA.per.Z)
Per.SC


## COGNITION

### specifying variables
MA.cog.Z$sync.contol <- ifelse(MA.cog.Z$Sync_Coor == "Sync - Control", 1, 0)
MA.cog.Z$sync.coor <- ifelse(MA.cog.Z$Sync_Coor == "Sync - Coordination", 1, 0)

### REML
Cog.SC <- rma(yi, vi, mods = ~factor(Sync_Coor) - 1, data = MA.cog.Z)
Cog.SC


## AFFECT

### specifying variables
MA.aff.Z$sync.contol <- ifelse(MA.aff.Z$Sync_Coor == "Sync - Control", 1, 0)
MA.aff.Z$sync.coor <- ifelse(MA.aff.Z$Sync_Coor == "Sync - Coordination", 1, 0)

### REML
Aff.SC <- rma(yi, vi, mods = ~factor(Sync_Coor) - 1, data = MA.aff.Z)
Aff.SC
```

```
# group size analyses

## BEHAVIOUR – REML
res.behsize.M <- rma(yi, vi, mods = GrpSizeMean, data=MA.beh.Z)
res.behsize.M

## PERCEPTION – REML
res.persize.M <- rma(yi, vi, mods = GrpSizeMean, data=MA.per.Z)
res.persize.M

## COGNITION – REML
res.cogsize.M <- rma(yi, vi, mods = GrpSizeMean, data=MA.cog.Z)
res.cogsize.M

## AFFECT – REML
res.affsize.M <- rma(yi, vi, mods = GrpSizeMean, data=MA.aff.Z)
res.affsize.M
```

Appendix B: Correlation Table for Study 2

Table B.1
Correlations Between Dependent Variables

	1	2	3	4	5	6	7
1. Cohesion	-	.44***	-.05	-.01	-.09	-.07	-.09
2. Positive affect	-	-	.09	-.08	-.10	.06	.01
3. Negative affect	-	-	-	-.06	.10	.11	.13
4. Convergent thinking	-	-	-	-	.05	.30***	.29**
5. Fluency	-	-	-	-	-	.34***	.33***
6. Creativity	-	-	-	-	-	-	.91***
7. Novelty	-	-	-	-	-	-	-

* $p < .05$ ** $p < .01$ *** $p < .001$

Appendix C: Supplementary Material for Study 3 and Study 4

C.1) Questionnaires

1.1 Control items and manipulation checks

1.1.1 Study 3

Familiarity effect control question: "*How often do you interact with people from this group outside practice?*" [5-point scale: (a) never, (b) once a month, (c) 2-3 times a month, (d) once a week, (e) more than once a week].

1.1.2 Study 4

Familiarity effect control question: "*Please rate how well you knew each participant before you met for this study*" [5-point scale: (1) I have never seen him/her before, (2) I have seen him/her before, (3) I have talked briefly with him/her, (4) I have spent time with him/her, (5) I know him/her very well].
Physical intensity manipulation check: "*Please rate how physically intense the movement activity was*" [7-point Likert scale: (1) not at all intense, (4) moderately intense, (7) very intense].

1.2 Cohesion

1.2.1 Study 3

Reddish's (2012) adapted version of the Inclusion of the Other in the Self scale (IOS; Aron et al., 1992): "*Please circle the letter that best represents how close you currently feel to the group of people you did the activity with*" [1-7 pictorial scale with two circles of increasing overlap indicating interpersonal interconnectedness between the participant and others in the activity].

1.2.2 Study 4

<u>Composite of four constructs</u>: Entitativity, trust and perceived similarity on 7-point Likert scale [(1) not at all to (7) very much]
Interconnectedness: Same IOS item as Study 3;
Entitativity: Nine items Reddish (2012) adapted from Denson et al. (2006), Lakens (2010), and Lickel et al. (2000): e.g. "*You consider this group as a coherent group*";
Trust: Three items from Jarvenpaa et al. (1998): e.g. "*The people in my group are very trustworthy*";
Perceived similarity: 12 modified items from the Homophily Scale (McCroskey et al., 2006): e.g. "*People in this group are similar to me*".

1.3 Affect

1.3.1 Study 3

Positive and Negative Affect Schedule (PANAS; Watson et al., 1998) [7-point Likert scale: (1) not at all, (4) somewhat, (7) extremely]
Four positive affect items (*alert, inspired, attentive, active*) and inclusion of '*happy'*;
Two negative affect items (*nervous, afraid*).

1.3.2 Study 4

PANAS: Same scale as Study 3
Six positive affect items (*alert, inspired, determined, attentive, active, happy*);
Five negative affect items (*upset, hostile, ashamed, nervous, afraid*).

C.2) Description of physical intensity manipulation in Study 4 (experimental study)

Prior to starting Study 4, we conducted a small pilot study to test different tempos (speeds) to ensure all three levels of intensity movements could be performed comfortably at the same tempo for a sustained duration of time. Participants performed all three movements at 45 beats per minute (bpm), 55 bpm, 65 bpm, and 75 bpm. The consensus was for the tempo of 65 bpm which was well suited for all three movements.

2.1 High intensity – Jumping jacks

Participants heard three beats played per repetitive cycle. Keeping their hands by their sides, they were instructed to jump out with their feet apart on beat 1, jump back in with their feet together on beat 2, and not move on beat 3.

2.2 Moderate intensity – Marching on the spot

Participants heard four beats played per repetitive cycle. Keeping their hands by their sides, they were instructed to start marching on the spot by stepping their right leg down on beat 1, left leg down on beat 2, right leg on beat 3, left leg on beat 4, and so forth.

2.3 Low intensity – Breathing on the spot

Participants heard four beats played per repetitive cycle. Keeping their hands by their sides, they were instructed to slowly inhale for four beats starting on beat 1, and slowly exhale for four beats starting on the following cycle (beat 1). To ensure participants were breathing in the intended way, we played an audio recording of when they should inhale and exhale which accompanied the beats.

C.3) Additional statistical results

Table C.1
Correlations Between Dependent Variables in Study 3 (Field Study)

	1	2	3	4	5	6
1. Cohesion	-	.41**	-.07	.11	.07	.07
2. Positive affect	-	-	.09	.07	-.10	-.14
3. Negative affect	-	-	-	.23	-.02	.04
4. Fluency	-	-	-	-	.61***	.65***
5. Creativity	-	-	-	-	-	.96***
6. Novelty	-	-	-	-	-	-

* $p < .05$ ** $p < .01$ *** $p < .001$

Table C.2
Correlations Between Dependent Variables in Study 4 (Experimental Study)

	1	2	3	4	5	6	7
1. Cohesion	-	.41***	-.10	-.04	-.05	-.14	-.07
2. Positive affect	-	-	-.01	.05	.03	-.10	-.05
3. Negative affect	-	-	-	-.29**	-.12	-.00	-.00
4. Convergent thinking	-	-	-	-	.32**	.31**	.28**
5. Fluency	-	-	-	-	-	.36***	.31**
6. Creativity	-	-	-	-	-	-	.95***
7. Novelty	-	-	-	-	-	-	-

* $p < .05$ ** $p < .01$ *** $p < .001$

Table C.3

Effect Estimates for Synchrony, Intensity and the Control Variables on Each Dependent Variable in Study 3

	Synchrony			Intensity			Age			Gender			Involvement duration			Interaction frequency		
DVs	*B*	*se*	*p*	*B*	*se*	*p*	*B*	*se*	*p*	*B*	*se*	*p*	*B*	*se*	*p*	*B*	*se*	*p*
Cohesion	-0.16	0.32	.635	0.68	0.32	.040 *	0.03	0.03	.359	-0.28	0.53	.601	-0.00	0.01	.823	0.29	0.13	.034 *
Positive affect	0.21	0.17	.290	0.12	0.17	.485	0.03	0.02	.033 *	-0.22	0.27	.421	0.00	0.01	.967	0.12	0.07	.079
Negative affect	-0.16	0.20	.462	0.21	0.22	.329	-0.00	0.02	.903	0.58	0.40	.162	0.00	0.01	.732	0.11	0.09	.222
Fluency	-0.26	0.07	< 001 ***	0.26	0.08	.001 **	0.01	0.01	.027 *	0.06	0.11	.612	-0.01	0.00	.037 *	0.01	0.03	.833
Creativity	-0.29	0.11	.053 *	0.22	0.12	.060	0.00	0.01	.925	-0.23	0.23	.326	-0.00	0.01	.527	-0.00	0.06	.988
Novelty	-0.28	0.10	.046 *	0.25	0.11	.021 *	0.00	0.01	.842	-0.31	0.21	.139	-0.00	0.00	.395	0.01	0.05	.770

* $p < .05$ ** $p < .01$ *** $p < .001$

C.4) R code for Study 3's (field study) analyses

```
setwd("C:/Users/Reneeta/Dropbox/PhD/Studies/Study3")
field = read.csv("Field.csv", header = TRUE)
str(field)

# packages
        library(multilevel)
        library(lme4)

# specifying variables
        field$activity <- as.factor(field$activity)
        field$female <- as.factor(field$female)


#   activity is a factor with six levels
        ##  0 = control (No movement - attend lecture)
        ##  1 = Capoeira
        ##  2 = TaeKwondo
        ##  3 = Pilates
        ##  4 = Yoga
        ##  5 = Zumba

#   synchrony is a numeric variable with four ratings
        ##  0 = no movement "nomove"
        ##  1 = movement but not synchronised "nosync"
        ##  2 = movement and somewhat synchronised "somesync"
        ##  3 = movement and highly synchronised "hisync"

#   age is the numeric age at the time of the experiment

#   female (gender) is a two level factor
        ##  0 = male
        ##  1 = female

#   involve_months is how long (in months) participants have been involved in the
group activity

#   interaction is how often participants interact with members outside of the activity
practice rated on a scale
        ##  0 = never
        ##  1 = once a month
        ##  2 = 2-3 times a month
        ##  3 = once a week
        ##  4 = more than once a week

#   hrmax is the maximum heart rate of the participant based on a formula using their
age
```

```
#   hrpercent is the percentage of the mean heart rate during the activity compared to
their age-dependent maximum heart rate


# scaling heart rate percent
        field$scaledHR <- scale(field$hrpercent)

# removing NAs
        field.1 <-
        na.exclude(field[,c("ID","activity","synchrony","age","female","involve_months
        ","interaction","hrpercent","cohesion","positive_affect","negative_affect","creati
        vity","novelty","fluency","scaledHR")])


# analysing each dependent variable

## COHESION

coh.controls <- lme(cohesion ~ age + female + involve_months + interaction,
random=~1|activity, data=field.1, control=list(opt="optim"), method="ML")
summary(coh.controls)

coh.model <- lme(cohesion ~ synchrony + scaledHR + interaction, random=~1|activity,
data=field.1, control=list(opt="optim"), method="ML")
summary(coh.model)


## POSITIVE AFFECT

pos.controls <- lme(positive_affect ~ age + female + involve_months + interaction,
random=~1|activity, data=field.1, control=list(opt="optim"), method="ML")
summary(pos.controls)

pos.model <- lme(positive_affect ~ synchrony + scaledHR + age, random=~1|activity,
data=field.1, control=list(opt="optim"), method="ML")
summary(pos.model)


## NEGATIVE AFFECT

neg.controls <- lme(negative_affect ~ age + female + involve_months + interaction,
random=~1|activity, data=field.1, control=list(opt="optim"), method="ML")
summary(neg.controls)

neg.model <- lme(negative_affect ~ synchrony + scaledHR, random=~1|activity,
data=field.1, control=list(opt="optim"), method="ML")
summary(neg.model)
```

CREATIVITY INDEX

```
create.controls <- lme(creativity ~ age + female + involve_months + interaction,
random=~1|activity, data=field.1, control=list(opt="optim"), method="ML")
summary(create.controls)

create.model <- lme(creativity ~ synchrony + scaledHR, random=~1|activity,
data=field.1, control=list(opt="optim"), method="ML")
summary(create.model)
```

NOVELTY INDEX

```
novel.controls <- lme(novelty ~ age + female + involve_months + interaction,
random=~1|activity, data=field.1, control=list(opt="optim"), method="ML")
summary(novel.controls)

novel.model <- lme(novelty ~ synchrony + scaledHR, random=~1|activity, data=field.1,
control=list(opt="optim"), method="ML")
summary(novel.model)
```

FLUENCY INDEX

```
fluency.controls <- glmer(fluency ~ age + female + involve_months + interaction +
(1|activity), data=field.1, control=glmerControl(optimizer=c("bobyqa",
"Nelder_Mead"), restart_edge = FALSE), family=poisson(link="log"))
summary(fluency.controls)


fluency.model <- glmer(fluency ~ synchrony + scaledHR + age + involve_months +
(1|activity), data=field.1, control=glmerControl(optimizer=c("bobyqa",
"Nelder_Mead"), restart_edge = FALSE), family=poisson(link="log"))
summary(fluency.model)
```