Review Article

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How Moving Together Binds Us Together: The Social Consequences of Interpersonal Entrainment and Group Processes

Abstract: Interpersonal entrainment has been shown to have a wide variety of social consequences which span far beyond those that could be considered purely pro-social. This work reviews all of the social effects of entrainment and the various explanations for them. The group formation framework emerges as a parsimonious account claiming that as we entrain our sense of self is temporarily diluted as an interdependent identity becomes more salient, thus leading to a range of social and psychological consequences which are pro-group. The sense of belonging arising from moving together is conducive towards pro-social behaviours; yet, it also makes the individual more susceptible to adopting the ideology of the group without critical thinking. We argue that the wide landscape of interpersonal entrainment's effects reflects its primary effect, de-individuation, and the formation of a common group identity amongst co-actors.

Keywords: Entrainment; Synchrony; Coordination; group processes; pro-sociality; joint action

> "Words are inadequate to describe the emotion aroused by the prolonged movement in unison that drilling involved. A sense of pervasive well-being is what I recall; more specifically a strange sense of personal enlargement; a sort of swelling out, becoming bigger than life, thanks to participation in collective ritual" - McNeill, (1997, p. 2)

Introduction

We regularly coordinate our movements together. We dance, sing, play music and even walk in time with each other (McNeill, 1995). Moving together in these ways has been shown to induce prosocial effects amongst those who take part, such as increased liking, helping and cooperation (i.e., Kokal, Engel, Kirschner, & Keysers, 2011; Reddish, Bulbulia, & Fischer, 2014). However, entrainment also has a much wider range of social consequences, affecting memory, attention, and joint action (Macrae, Duffy, Miles, & Lawrence, 2008; Valdesolo & Desteno, 2011), as well as behaviours that could be perceived as quite antisocial (e.g., Wiltermuth, 2012a,b).

There have been several recent reviews (Rennung & Göritz, 2016; Vicaria & Dickens, 2016) and a meta-analysis (Mogan, Fischer, & Bulbulia, 2017) exploring the effects of entrainment. However, these reviews have focused on the pro-social effects of entrainment while those effects that are not clearly pro-social

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have been largely overlooked. This work, therefore, reviews all the relevant findings on the social effects of entrainment, including the large body of work exploring effects that would not typically be considered pro-social. In doing so we are the first to identify that all of these findings are also effects shown to follow from group formation and identification. The findings of this field are synthesised into a coherent theoretical argument for how and why entrainment fosters the wide range of social effects it does, via cultivating group formation and identification. By integrating all findings from the interpersonal entrainment literature, the present review suggests a focus on pro-group instead of pro-social effects.

Outline and contents

Throughout this paper, we first define exactly what we mean by moving together in time (or entrainment) and discuss how this fits within the wider joint action literature. Theories of the evolutionary function(s) of entrainment are then explored, which suggest that entrainment provided adaptive advantages for early hominid groups. We then assess the social psychological literature on group formation, identification and maintenance, which highlights how entrainment may be a suitable social mechanism to foster a common group mentality amongst co-actors. The empirical work on entrainment's social effects is then reviewed, analysing the relationship between the findings. In the course of this review, one common denominator emerges – the consequences of entrainment are often also consequences of group belonging, or in/out-group effects. We assess the evidence for how entrainment could have the social effects it does under this group formation framework. This assessment suggests that changes in how we construe our social identities may make a better explanation than increases in overlap and affiliation with our co-actors.

What is entrainment?

Entrainment refers to temporally coupled or synchronised systems, and it is the process of things moving in time together. Entrainment is present throughout the known universe, from the pull of the stars on their planets, to firefly flashing, bird flocking, and fish schooling (Strogatz, 2003). Our bodies entrain, both within themselves and with the outside world (Moore-Ede, Sulzman, & Fuller, 1982). We also commonly entrain with each other, and our postural sway, breathing and even heart rate can all spontaneously synchronise with those around us (see, Allsop, Vaitkus, Marie, & Miles, 2017). We also intentionally coordinate our movements, for example when we dance, walk and sing in time with each other (McNeill, 1995), and this is often referred to as interpersonal entrainment (IPE).

IPE is essentially a special class of joint action. Joint action can be defined as two or more people coordinating their actions in space and time to produce a joint outcome (Knoblich, Butterfil, & Sebanz, 2011). IPE can be distinguished from other forms of coordination through its reliance on synchronising to a common rhythm. For example, mimicry is another form of coordination whereby one agent spontaneously imitates the actions of another (Lakin & Chartrand, 2003). Both IPE and mimicry involve at least two people moving in the same way (Chartrand & Lakin, 2013), and both seem to foster similar social effects (Vicaria & Dickens, 2016). However, while mimicking involves a person coordinating their behaviour to match that of another (usually after a short lag of around 1-3 seconds) and is typically unconscious, it does not involve people coordinating their actions in time to a common rhythm. This synchronising to a common rhythm is a fundamental and distinguishing component of IPE. Throughout this paper, it is IPE and its social effects that we are primarily interested in.

IPE can be defined as the synchronisation of organisms to some external rhythm (Phillips-Silver, Aktipis, & Bryant, 2010). Synchronisation refers to the process of two or more individuals coordinating their rhythmic behaviour to a stable phase, typically either in- or anti-phase (Condon & Ogston, 1966). In-phase synchronisation is a special kind of IPE, where two agents move in the same way at the same time. An example is two people walking together, where each person lifts their leg at the same time. In contrast, anti-phase would be where one person was bringing their leg down when the other is lifting their leg up. Both types of synchronisation constitute strong attractor states, that is, stable states to which periodic

systems tend to naturally drift towards. Anti-phase is generally less stable than in-phase, but can still be maintained across a range of amplitudes and frequencies (Kelso, 1995). The remaining range of less stable phase relationships is typically referred to as out-of-phase or asynchronous (Clayton, Sager, & Will, 2005).

It is also worth noting that coordinating to a common rhythm is not a uniquely human trait, but is seen throughout the animal kingdom. Examples include the phase synchronisation of firefly flashes (Strogatz, 2003) or the synchronous surfacing of bottlenose dolphins (Connor, 2006), which is more common during bouts of intense social behaviour. This suggests that synchronous activity may be an adaptive social signal in some species. What's more, it is thought to be ubiquitous among human societies. Today, it is most often seen in dance, drill, music, speech, and sport, but it has been shown to be present in some form or other in even the most remote of tribes (McNeill, 1995). IPE is believed to have been present since early on in our evolutionary history; rock art dating back to the prehistoric era shows the presence of dancing and the oldest known remains of a musical instrument date back over 40,000 years (Conrad, Malina & Munzel, 2009; Ehrenreich, 2007). Such universal behaviours likely served some important adaptive functions throughout early human history (Schater, Wagner & Gilbert, 2007). Therefore, the ubiquity of entrainment begs the question: what was its evolutionary function(s)?

The evolutionary role of IPE

Many evolutionary theorists have hypothesised that through continuous moving together in time (such as drumming, singing or dancing together), early humans became better equipped to engage in group behaviours, and that this significantly contributed to the advancement of the species. Cross (2009) describes music-making as an evolved process that signals cooperation and allows individuals to share their perspectives and intentions. Merker (2000) proposed that synchronous chorusing evolved to display coalition strength amongst groups of early hominid males, enabling them to better defend their territory and attract females. Hagen and Byrant (2003) suggested that making music and dancing originated in displays between socially meaningful groups, and that these displays then evolved into a signalling system allowing groups to communicate internal stability. This allowed them to better act collectively as a unit and to establish meaningful relationships, including both cooperative relationships within groups and competitive/hostile ones between groups. Lastly, the music-dance cooperation hypothesis claims that music and dance evolved to facilitate group living by increasing cooperative tendencies between those involved (Reddish, 2012). In other words, music and dance have a group-level benefit in that they foster bonding between those involved, facilitating collaborative actions and cooperation.

These evolutionary theories all speculate as to what advantages engaging in IPE may have offered our ancestors, and why it might have persisted throughout and across cultural and temporal lines. While not identical, these theories do share the common theme that IPE promotes the formation and/or maintenance of a collective unit or group. Essentially, IPE cultivates and/or strengthens a common group mentality amongst co-actors, which offers adaptive advantages to those individuals. This emerging collective unit could have afforded a multitude of group-level benefits to our early ancestors. Some theories even suggest that before language, IPE may have been an effective way to indicate a shared collective affiliation with individuals within the same group and to signal a shared social identity across different groups (McNeill, 1995). Social identity theory predicts that a range of social consequences follows from individuals viewing themselves in common group terms (Tajfel, 1982). Could this group-formation framework provide a plausible explanation as to why IPE results in a wide range of social effects? Before we evaluate whether this is possible, we will firstly explore how groups are believed to be formed and evaluate whether IPE possesses the necessary qualities to allow group formation and identification.

IPE and group processes

Groups are believed to be formed and maintained in a number of different ways. This can be through interpersonal attraction, the perception of a shared social category, and a shared positive interdependence

towards achieving a common goal (Allport, 1954; Gartner, Mann, Murrell, & Dovidio, 1989; Hogg & Williams, 2000; Rabbie & Horwitz, 1969). IPE can foster attraction between co-actors (Hove & Risen, 2009), and those who entrain do view themselves and their co-actors more in interdependent terms (Good, Choma & Ruso, 2017). IPE also offers co-actors the chance to cooperate towards a common, positively interdependent goal (i.e., successfully coordinating requires all involved parties to move together), which is thought to lead people to perceive each other as similar, co-active members of the same group (Good et al., 2017; Kirschner & Tomasello, 2010). Even when not explicitly driven by a common goal and/or intention (e.g., when people spontaneously start to walk in-phase), IPE still involves cooperation on a joint action, positive interdependence (all parties must succeed in order to be coordinated together) and a number of shared conditions across modalities (i.e., visual, auditory and kinaesthetic cues).

Tajfel, Bilig, Bundy and Flament (1971) suggest that sharing an attentional focus can lead individuals to perceive each other as part of a common group. Some argue that this sharing of an attentional focus may be what increases social bonding following joint action (Wolf, Launay, & Dunbar, 2016). IPE, therefore, seems to have the relevant attributes to cause those who engage to experience a re-categorisation of their perceptions of self and co-actors as common group members. Self-categorisation theory suggests that people come to view themselves less as unique individuals and more as group members as a common group is formed. Depersonalisation of this nature is believed to underlie phenomena like group cohesiveness, cooperation, and altruism (Turner, Hogg, Oakes, Reicher, & Wetherell 1987). Evidence also suggests that IPE de-individuates individuals (Cross, Atherton, Wilson, & Golonka, 2017), leading them to construe both themselves and their co-actors more in group terms than in individual ones. Other research has also shown that after IPE co-actors construe the relationships between people in more entitative terms (i.e., viewing co-actors more as a part of a tightly knit group than as separate individuals, as shown in Fessler & Holbrook, 2016; Reddish et al., 2013; 2016).

IPE, therefore, seems capable of causing the formation of a common group mentality amongst co-actors. It may be that when two or more people move together in time, they begin to view themselves and their co-actors in common group terms, which leads to emotions, thoughts, and actions in the interest of the emerging collective. This idea has long-standing theoretical roots. As early as 1912, Durkheim's work on collective effervescence suggested that moving together in time creates a sense of belonging to a newly formed social unit (Durkheim & Swain, 2008). This idea was also presented by McNeill (1995), who advocated that moving together in time acts as a kind of social glue (which he refers to as 'we-ness') that bonds individuals and leads people to act in the interest of the collective. More recently, three specific mechanisms by which IPE fosters psychological effects have been suggested: a) a blurring of self-other overlap, b) a strengthening of social affiliation, and c) a re-categorisation of self-construal.

Hove (2008) suggested that IPE causes a blurring between the boundaries of self and other, meaning that an individual's perception of one's self becomes blurred with that of a co-actor, most commonly measured using the Inclusion of Other in Self scale (IOS; Aron, Aron, & Smollan, 1992). Self-other overlap is intimately linked to group processes, and measures of overlap are used as indicators of one's relation to a group (Schubert & Otten, 2002). The degree of self-other overlap is also thought to play a role in social bonding in primates (Galinsky, Ku, & Wang, 2005). Increases in self-other overlap could be a part of the mechanisms by which IPE has fostered adaptive group formation throughout human evolution. Similarly, Wiltermuth and Heath (2009) proposed that IPE's effects are a consequence of it strengthening social affiliation amongst co-actors. That is, people's perception of and affiliations towards their co-actors (most commonly measured using self-reported ratings of closeness, similarity and connectedness) change as a result of IPE.

Group formation and categorisation is thought to be facilitated by increased perceived similarities to group members (Tajfel, 1982), so these increases in social affiliation could be a mechanism by which IPE fosters a common group mentality amongst co-actors. Both the affiliation and overlap hypotheses describe a process by which we come to think of each other as more alike following IPE, which then directly mediates behaviours such as cooperation. Indeed, much research combines measures of self-other overlap and social affiliation into single constructs that are often called social bonding (Reddish, Tong, Jong, Lanman, & Whitehouse 2016; Tarr, Launay, Cohen, & Dunbar, 2015; Wiltermuth, 2012b). Therefore, we will refer to self-other overlap and social affiliation jointly as the social-bonding explanation.

More recently, researchers have begun to discuss how moving in time with each other leads us to not only lessen social distances between and change evaluations of our co-actors, but to reclassify the way we see ourselves and our co-actors in common group terms (Cross et al., 2017; Good et al., 2017; Rabinowitch & Meltzoff, 2017a; Tungenc & Cohen, 2016b; Wolf, Launay, & Dunbar, 2016). That is, IPE acts as a cue towards common group membership, which leads to typical group effects such as in-group favouritism (Cirelli, 2018). We will refer to this idea as the social-identity explanation. It is typically measured using self-reported ratings of de-individuation (how much one feels like an individual versus a group member) or entitativity (whether one perceives others as individuals or part of a group). Figure 1 illustrates the proposed paths by which IPE might lead to other social effects in each explanation.
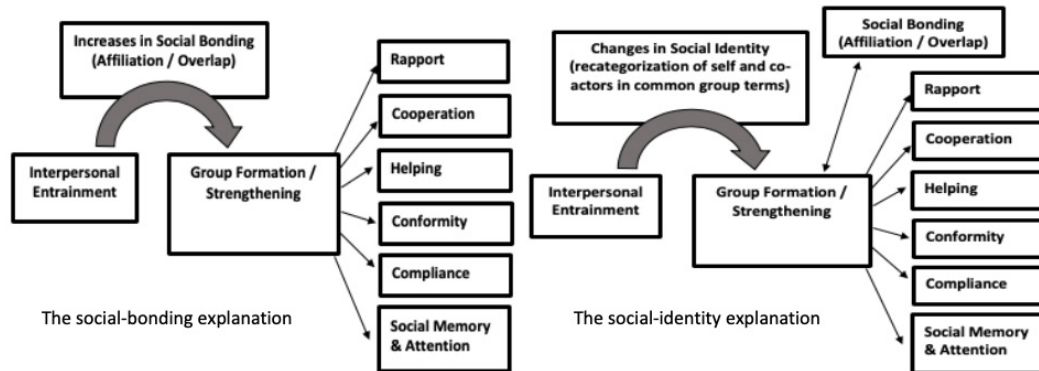

Figure 1. The group-formation framework and the social-bonding versus social-identity explanations. The group-formation framework suggests that interpersonal entrainment (IPE) has the social effects it does because following IPE co-actors view each other as common group members, which leads to typical group effects such as in-group favouritism. The social-bonding explanation (on the left) suggests that this is caused by an increase in affiliation and/or overlap amongst co-actors. The social-identity explanation (on the right) suggests that this is caused by co-actors recategorising their own self-construal in less independent (individual, me and you) and more interdependent (common group, us) ways. The social-bonding explanation sees increases in affiliation and overlap with co-actors as an integral part of the process, which is necessary for entrainment to lead to other social effects such as increased cooperation. On the other hand, the social-identity explanation places increases in social affiliation and overlap as an auxiliary effect that, while not strictly necessary to lead to other effects, may in turn further strengthen the emerging collective. In summary, while the social-bonding explanation posits social bonding as a crucial mediator (meaning it must always predate other effects), the social-identity explanation sees it as an additional effect (which may then encourage other effects, such as increased cooperation).

The social-bonding explanation suggests that a tightening of affiliation and increased overlap amongst co-actors directly drives individuals to act in pro-social ways towards one another. Here, changes in affiliation/overlap are thought to drive the other effects and are therefore crucial to the process, meaning we should not see greater cooperation, for example, unless it is preceded by social bonding. In contrast, the social-identity explanation suggests that IPE de-individuates people, leading them to view themselves and their co-actors in less individualised and more interdependent ways. Here, changes in social affiliation and self-other blurring are auxiliary effects of IPE, meaning it is possible to see other effects of IPE in the absence of social bonding (although social bonding may further strengthen an emerging group).

This is an important distinction that will allow us to tease apart evidence in favour of each particular explanation. Thus, in the following sections, we will first ascertain whether the overall group-formation framework (the idea that the social effects of IPE are a consequence of individuals classing each other as part of a common group) can account for the plethora of socio-cognitive effects of IPE. Next, we will evaluate which specific explanation for group formation following IPE (i.e., the social-bonding explanation or the social-identity explanation) is better supported. We now turn to review the wide range of psychological effects shown to follow IPE.

All the effects of IPE – the review

Relevant papers were located by conducting a literature search in a large academic database (PsycARTICLES, December 2017) using the following keywords: synchrony, interpersonal sync*, movement sync*, social entrainment, interpersonal entrainment, interpersonal coordination. All papers that explored the social consequences of moving in time with each other were included. This was defined as any article that investigated the interpersonal effects of engaging in IPE (e.g., how entrainment affects interpersonal processes such as cooperation, joint action and social memory and evaluations). Additionally, work exploring how group identification affects the entrainment process (e.g., how group membership affects entrainment) was of interest and therefore included. Further relevant papers were located following an ancestry approach (earlier papers cited by a given paper) and a descendancy approach (subsequent papers by authors of, or citing, a given paper). The relevant work is synthesised throughout the following sections, and further details of individual studies can be found in Table 1.

Table 1. A summary of the methodology and findings of the reviewed studies.

Article	Entrainment Method	DV & Results
Hove & Risen (2009) Exp. 1	Finger tapping (150 secs) Adult participants (tested individually) tapped in time to a visual metronome along with the experimenter.	How much participant liked the experimenter (self-report). The degree of interpersonal synchrony predicted how much the participant liked the experimenter.
Hove & Risen (2009) Exp. 2	Finger tapping (10 mins). Adult participants (tested individually) tapped along to a visual metronome while the experimenter tapped along either synchronously or asynchronously. In the control only participants tapped, but the experimenter was still present.	How much participant liked the experimenter (self-report). Participants in the synchrony condition gave higher ratings of likeability for the experimenter than those in the other conditions. The degree of coordination predicted the degree of likeability.
Hove & Risen (2009) Exp. 3	Finger tapping (10 mins). Adult participants (tested individually) tapped along to metronome (experimenter just observed), while a separate visual target pulsed either synchronously or asynchronously.	How much participant liked the experimenter (self-report). No differences were found between conditions, and neither tapping manipulation led participants to like the experimenter more.
Launay, Dean & Bailes (2014) Exp. 1	Tapping (5 mins). Adult participants (tested individually) were told to synchronise taps with sounds they heard while watching a video of a co-actor. In the control they were told not to sync with sounds, but to tap at different times.	How much participant liked their partner (self-report) and eye contact. Participants in the synchrony condition maintained more eye contact with their partner and rated them as more likeable. There was also a significant correlation between synchrony indexes and likeability scores.
Launay, Dean & Bailes (2014) Exp. 2	Tapping (5 mins). Adult participants (tested individually) tapped in sync with a computer, and half were led to believe it was another person.	How much participant liked their partner (self-report) and eye contact. Tapping with a human partner replicated the results of Exp. 1, but there was no difference (or correlation) in ratings of likeability when they were aware they were tapping with a computer.
Valdesolo & DeSteno (2011)	Tapping (150 secs). Adult participants (tested individually along with confederates) tapped along to a beat while a co-actor tapped along synchronously or asynchronously.	Affiliation, compassion (self-report) and helping behaviour (time given to help another participant complete a task). Those who had moved in synchrony reported greater affiliation and compassion with the confederate and also chose to help them more frequently and for longer.

Article	Entrainment Method	DV & Results
Anshel & Kipper (1988)	Group singing (not reported, session lasted 1 hour). Adult participants (tested in groups of 24) either sang along in synchrony to a familiar song or synchronously read poetry. In the controls participants passively listened to the same songs or watched a documentary in their groups.	Trust (self-report) and cooperation (prisoner's dilemma economic game). Those who were exposed to music (whether actively or passively) scored significantly higher on measures of trust than those in the other conditions. Those who had participated in synchronous activity cooperated more than those who had participated in the other conditions.
Launay, Dean & Bailes (2013)	Tapping (3 mins x 4 rounds). Adult participants (tested individually) played four rounds of a tapping game where they had to tap synchronously on two rounds and asynchronously on the other two, with sounds that they believed represented other people's taps.	Trust (trustee economic game, taken between each round of tapping game). The best model for predicting trust used ratings of success and ratings of synchronisation, actual measures of synchronisation were not a good predictor.
Wiltermuth & Heath (2009) Exp. 1	Walking (not reported). Adult participants (in groups of 3) walked in-step, in the control participants walked normally (out of synchrony).	Connectedness and trust (self-reports), cooperation (weak link economic game). Those who walked in step showed more cooperation in the initial round of an economic game than those who had walked normally. They also felt more connected to and trusted their fellow participants more but did not report greater positive affect.
Wiltermuth & Heath (2009) Exp. 2 & 3	Cup waving and singing (not reported). Adult participants (in groups of 3) synchronously sang along to the Canadian national anthem, and some also waved cups from side to side. There was also an asynchronous condition in which participants waved and sang out of synchrony, as well as a control where participants just listened and silently read the lyrics while holding a cup statically over their head.	Affiliation and entitativity (self-reports), cooperation (weak link and public goods economic games). Participants in both of the synchronous conditions cooperated significantly more than those in the other two conditions in the economic games. Synchronous movements combined with synchronous vocalisations did not produce more cooperation than synchronised vocalisation alone. Synchronous participants also reported greater feelings of being on the same team, trust and similarity. Feelings of being on the same team were shown to partially mediate cooperation.
Reddish, Fischer & Bulbulia (2013) Exp. 2	Chanting (6 mins). Adult participants (in groups of 3) read out words either sequentially or synchronously, paced by metronomes for the first 20 seconds of the task.	Affiliation, overlap, entitativity and trust (self-reports), cooperation (stag hunt game). Those who had chanted synchronously cooperated significantly more than those who had chanted sequentially. No self-report measures differed between conditions and only trust correlated with cooperative behaviour.
Cross, Wilson & Golonka (2016) Exp. 1 & 2 follow ups	Moving joysticks (6 mins). Adult participants moved joysticks (in pairs) horizontally either in-phase or anti-phase (using either a point light display or mirrors to coordinate) or coordinated different movements (vertical and circular) to the same rhythm. In the control condition, they made different movements out of time with each other.	Affiliation and overlap (self-reports), cooperation (public goods economic game). Those who had coordinated cooperated more during an economic game than those who had moved out of phase. There were no differences in either affiliation or overlap change score amongst conditions.

Article	Entrainment Method	DV & Results
Cross, Atherton, Wilson & Golonka (2017) Exp. 1 & 2	Imagined walking (2 mins). Adult participants (groups of 3 or 4) imagined walking either alone or synchronously with each other for two minutes, either with or without video demonstrations.	Affiliation (self-report), cooperation (public goods economic game). There were greater increases in social affiliation amongst those who had imagined coordinating, but these increases in affiliation did not lead to greater cooperation. In Exp. 2, individuals who had imagined coordinating also reported feeling more like a group member and less like a unique individual post task. This deindividuation correlated with greater affiliation.
Lang, Bahna, Shaver, Reddish, and Xygalats (2017)	Arm movements (5 mins x 3 rounds). Adult participants (tested individually) performed arm movements either in front of a blank wall or a video of a confederate (high vs low synchrony). Then self-reported measures and pain thresholds were taken, and an economic game played.	Affiliation, overlap (self-reports), trust, (trustee economic game) and EOS activation (pain threshold). Those in the synchrony condition rated the confederate as more likable and trusted them more in the economic game. Liking did not mediate trust. Overlap was found to mediate liking but not cooperation/trust. Pain threshold (an assay for endogenous opioid system (EOS) activation), was shown to mediate trust but not liking.
Tarr, Launay & Dunbar (2016)	Dancing (13 mins). Adult participants (tested in groups of 4) danced either in synchrony, partial synchrony or asynchrony. This was followed by measures of pain threshold, cooperation and social-bonding.	Overlap, affiliation (self-reports), cooperation (weak link economic game) and EOS activation (pain threshold). Those in the synchrony condition had a higher pain threshold suggesting greater EOS activation. Those in the synchrony condition also reported greater bonding than the partial synchrony condition (though asynchrony condition didn't differ from either); there were no differences between conditions in the subsequent economic game.
Pearce, Launay, MacCarron, Dunbar (2017)	Singing (3 classes over 7 months). Adult participants in education/community classes involving either singing, crafts and creative writing were assessed for relational and collective bonds multiple times over 7 months.	Relational (individual level) and collective (group level) bonds to classmates (self-reports). Those in the group singing classes developed relational (individual-level) bonds more quickly than crafters (but not creative writers), though they levelled out to a similar level over time. Singers possessed a greater degree of collective (group-level) bonds than those in crafts and creative writing classes, both overall and initially. Amongst singers, greater bonding occurred at a group than an individual level; furthermore, bonding at the group level occurred before bonding at the individual level.
Reddish, Fischer & Bulbulia (2013) Exp. 1	Limb movements (6 mins). Adult participants (in groups of 4) made three movements in time to a metronome (either synchronously or asynchronously). Shared intentionality was also manipulated. Instead of a metronome, some participants were told to work together to create the desired movements whilst the control group watched a video of this task being performed by others.	Affiliation, overlap, entitativity and trust (self-reports), cooperation (public goods economic game). More cooperation was seen in the synchronous conditions than the asynchronous or control condition. Overlap was significantly different between the synchronous movements/shared intentionality condition and all other conditions (no other self-report was significant). Only trust significantly correlated with cooperation.

Article	Entrainment Method	DV & Results
Reddish, Fischer & Bulbulia (2013) Exp. 3	Foot tapping (6 mins). Adult participants (in groups of 3) stepped on foot pedals synchronously, sequentially or asynchronously, while also moving the same arm forward. For half of the groups, participants were asked to move in time to the metronome (individual goal). For the other half, the metronome was only initially present, and participants then had to coordinate their behaviour with each other (group goal). A control condition was performed consisting of an asynchronous version of the task.	Affiliation, overlap, entitativity and trust (self-reports), cooperation (stag hunt economic game). Those who moved in synchrony in the group goal condition cooperated significantly more than those who moved in either the sequential or asynchronous conditions; there was no difference in cooperation between these two conditions. No significant differences in cooperation were found in the individual goal conditions. Measures of similarity, overlap, and entitativity combined were greater post synchrony and significantly correlated with cooperation.
Hu, Hu, Li, Pan & Cheng (2017)	Key pressing (18 mins). Adult participants (tested in pairs), were occluded by a screen and pressed a key on a keyboard, in the coordinated condition they were instructed to press the keys in time with each other every 500 ms. In the control condition participants did the task with a computer.	Similarity (self-report), helping (self-report of donating time) and shared intentionality (shared flow of thoughts and ideas). There was greater reported helping and shared intentionality (but not similarity) amongst those in the coordinated condition. Greater interbrain synchrony was also seen in the coordination task (which correlated with the measure of shared intentionality).
Rabinowitch and Meltzoff (2017a)	Swinging (7.5 minutes). Children (aged 4, tested in pairs) swung side by side on swings either synchronously or asynchronously. Those in the control condition did not swing. They then did a resource allocation task, where they had to share out resources using fixed allocations.	Resource allocation (sharing toys with partner). Swinging either synchronously or asynchronously increased generosity towards their partner compared to those in the control, as long as it did not require them to reduce their own share or assign resources unequally. Authors suggest more generous sharing after movement reflects recategorisation of partner as an 'in-group' peer.
Rabinowitch & Meltzoff (2017b)	Swinging (7.5 minutes). Children (aged 4, tested in pairs) swung side by side on swings either synchronously or asynchronously, in a control condition they did not swing. They then had to simultaneously push buttons in tandem in order to see an animated image and pass objects to partner through a hole using an apparatus.	Cooperation/joint action (novel behavioural measures), intentional communication (observer rated). Children in the synchronous condition were significantly more successful on the button press task than the other groups and were significantly faster on the give and take task. Children in the synchrony group also displayed greater intentional communication (measured by exaggerated hand movements) than those in the other conditions.
Cirelli, Einarson & Trainor (2014) Exp. 1 & 2.	Bouncing (145 seconds). Infants (aged 14 months, tested individually) bounced up and down in time to music along with the experimenter either in-phase, anti-phase or out of time.	Helping behaviour (behavioural task). Infants were significantly more helpful following synchronous bouncing compared to out of sync bouncing for tests of spontaneous but not delayed helping. Anti-phase bounced infants showed as much helping behaviour as those bounced in-phase.
Cirelli, Wan Spinelli & Trainor (2017)	Bouncing (140 seconds). Infants (around 14 months, tested individually) were strapped onto an assistant and bounced along with the experimenter, either synchronously or asynchronously, to nature sounds rather than music.	Helping (3 behavioural tasks). Infants who bounced synchronously handed back significantly more objects than asynchronously bounced infants in the helping tasks. There were no group differences in spontaneous helping but synchronously bounced infants showed significantly greater delayed helping. This showed that music was not necessary, although greater fussiness was seen without it.

Article	Entrainment Method	DV & Results
Kirschner and Tomasello (2010)	Musical joint action (3 minutes). Children (aged 4-5, in pairs) walked with synchronised steps playing a basic instrument in time with music while singing a song. In the control condition they walked or crawled and jumped toy frogs in non-synchronous ways.	Spontaneous helping (picking up marbles, observer rating), spontaneous cooperative problem solving (novel behavioural task). Children helped one another more after experimental task by picking up dropped marbles, children in the synchronous condition also displayed greater cooperative problem solving.
Tugenc & Cohen (2016a)	Clapping and tapping (45 seconds). Children (aged 4-6 in pairs) alternately clapped and tapped with both hands in time with beats heard through headphones. They did this either in synchrony, or asynchronously. Mutual smiles and eye contact during the task were also recorded.	Emotional experiences (self-report), mutual smiles and eye contact (observer ratings) and spontaneous helping (novel behavioural task). The odds of children picking up dropped fish food for their partner were significantly greater for those in the synchronous condition. While individual and mutual smiles, and mutual eye contact occurred significantly more in the synchronous condition, no difference regarding emotional experience during the helping task or enjoyment of the game.
Rabinowitch & Knapf-Noam (2015)	Tapping (3 minutes). Children (age 8, tested in pairs), tapped in time with an animated bouncing ball shown on a screen. Tapping occurred either synchronously, asynchronously, or in the control condition where children did not tap.	Similarity, overlap (self-reports). Children that tapped synchronously with one another had significantly higher perceived similarity and overlap scores than both other groups.
Kirschner & Illari (2013)	Drumming (6 x 30 secs). Children (aged 3.5 years, tested individually) performed a drumming task where they were drumming along with an experimenter who was either in full view or behind a barrier. Alternatively, they drummed alone with an experimenter behind a barrier who was drawing. Children in all conditions heard a recorded playback beat. The children were not instructed to synchronise with experimenters' drumming. This movement manipulation was performed once before each of the dependent measures.	Helpfulness (behavioural task), Willingness to share (spontaneously sharing of cookies). No difference in either of the pro-sociality measures found between movement conditions.
Kokal, Engel, Kirschner & Keysers (2011)	Drumming (16 mins). Adult participants (tested individually) learned to drum to a syncopated rhythm. They then played this rhythm while undergoing FMRI along with what they thought were two experimenters, one of them drumming in sync and the other out-of-sync.	Liking (self-report), helping (picking up 'dropped' pens). Greater helping was observed towards an experimenter who was believed to have been drumming in synchrony with participants, but only by those who more easily picked up the rhythm. Participants also reported liking the experimenter who they had drummed in synchrony with more and having more fun in these trials.
Tarr, Launay, Cohen & Dunbar (2015)	Body movements (10 min). Brazilian high school students (in groups of 3) performed movements (either full body or just hand) in time to music either synchronously or not. Bonding was measured towards both those present (in-group) and those not present (out-group).	EOS activation (pain threshold) and bonding to the group (self-report). Those who had moved in synchrony felt more affiliated than those they had moved with but not towards those not present.
Cirelli, Wan & Trainor (2014)	Bouncing (140 seconds). Infants (14 months old, tested individually) were bounced synchronously in time to music with an experimenter while an assistant just observed. In the control condition an experimenter bounced out of synchrony with them.	Helping and sharing (behavioural tasks). In-phase bounced infants showed significantly more spontaneous helping towards the experimenter they had been bounced with, this was restricted to the person they moved with and did not extend to the observing assistant.

Article	Entrainment Method	DV & Results
Reddish, Bulbulia & Fischer (2014) Exp. 1.	Limb movements in time to a metronome (6 min). Adult participants (in groups of 3 or 4) made limb movements in time to a metronome either synchronously or asynchronously. In a control condition, participants watched a video of this task being performed in synchrony by others.	Affiliation, overlap and self-construal (self-reports), helping behaviour (volunteering time). Those who moved in synchrony offered more help than those in the control condition (no significant difference between the asynchronous condition and either of the other conditions). It made no difference whether the help requester was involved in the movement or not (in half of all groups they were involved in the movement and for the other half they were introduced afterwards). None of the self-report measures showed significant differences between conditions.
Reddish, Bulbulia & Fischer (2014) Exp. 2.	Foot tapping (6 mins). Adult participants (in groups of 6) were split into two groups; half performed a CRM task and half a control task. Participants had to press a foot pedal in synchrony, initially primed by a metronome. In the control condition, participants did a cooperative jigsaw puzzle task.	Affiliation, overlap and entitativity (self-reports), cooperation (Tajfel's group-level economic game). Those who performed the coordination task gave significantly more money to the other group in a proceeding economic game than those who had completed the puzzle task (who split money roughly equally between groups). Synchronous movements did not have any effect on self-report measures.
Cirelli, Wan & Trainor (2016)	Bouncing (140 seconds). Infants (14 months old, tested individually) first observed either an affiliative or a neutral relation between experimenters 1 and 2. They were then bounced to music with experimenter 1 either synchronously or asynchronously.	Helping (behavioural task). Infants who were bounced synchronously and saw an affiliative relationship between experimenter 1 and 2 helped experimenter 2 significantly more than those who bounced asynchronously, though this did not hold for those who saw a neutral relationship between experimenters.
Reddish, Tong, Jong, Lanman & Whitehouse (2016)	Stepping (4 mins). Adult participants (in groups of 3 or 4) were first primed as being members of the same group (university) and then performed either synchronous or asynchronous stepping. They were then asked to donate their time to complete a survey for another student who was either a member of the same or different university.	Social affiliation, overlap, entitativity and group identification (self-reports) and helping (offering time). Participants were more willing to help post synchrony (cf asynchrony) and were more willing to help in-group members overall. They were no more likely to help an in-group member post synchrony than asynchrony, but were more likely to help an out-group member. No differences in the amount of time offered were found and whether participants followed through with their offer to help was not reported. Participants in the synchrony condition also reported greater social-bonding and entitativity with the group than those in the asynchrony condition. Mediation analysis showed that entitativity mediated social-bonding, though social-bonding did not mediate helping.
Wiltermuth (2012a) Exp. 1	Walking (not reported). Adult participants walked either in-phase, anti-phase, or normally with the experimenter.	Affiliation and overlap (self-reports). Those in the synchronous condition reported greater social bonding towards the experimenter.
Wiltermuth (2012a) Exp. 2	Walking (not reported). Adult participants walked either in-phase, anti-phase, or normally with the experimenter; in another condition they walked in-phase with a different experimenter.	Compliance (complying to request). Those in the synchronous condition killed more bugs when asked to do so by the experimenter they had walked in synchrony with than in any other condition.

Article	Entrainment Method	DV & Results
Wiltermuth (2012b)	Cup waving and singing (3 minutes). Adult participants (in groups of 3) swung cups in time to instrumental music, either synchronously or asynchronously. In a control condition they simply held the cups statically while listening to the music. After the task, participants could choose the music the next group would perform to. In some conditions a confederate co-actor asked the participants to choose a noise blast.	Social affiliation and overlap (self-reports), compliance (complying to request). Those who had moved in synchrony were more likely to choose the noise blast than participants in the other conditions upon the co-actor's request. Those in the synchronous condition also saw an increase in social bonding compared with the other conditions. Social bonding partially mediated synchrony's effects on compliance.
Macrae, Duffy, Miles & Lawrence (2008)	Hand movements (2 mins). Adult participants (tested individually) moved their hand to a metronome beat, either in- or anti-phase, with an experimenter who was also speaking a series of words. In the control condition only, the participant did the movement task.	Memory (test). Better recall post in-phase than anti-phase or solitary movements. Also, more likely to correctly identify the experimenter from a line-up following in-phase movement.
Woolhouse & Lai (2014)	Tapping (30 mins). Adult participants (tested individually) had to tap along to a beat while watching videos of either one or two dancers, who danced in time with either the same or different music.	Attention (eye tracking). Participants spent more time looking at dancers that were synchronised with the music they were listening and tapping to than those who were not. They also spent more time looking at the head of these individuals than other areas.
Woolhouse, Tidar & Cross (2016)	Dancing (8 mins). Adult participants (tested in groups of 10) danced in time to different music being played through headphones (5 people each piece), in such a way that all participants came close to each other. While dancing, participants wore different coloured sashes with symbols on them.	Surprise memory (test). Those people who danced to the same music were better able to identify each other's correct sash colour and symbol than they were for those who danced to different music.
Miles, Nind, Henderson & Macrae (2010)	Arm curls (3 mins). Adult participants (tested individual) performed arm curls together with a confederate either in or anti-phase. Throughout the task they were being fed words through an earpiece to repeat out loud.	Memory (test). Following the movement task participants were asked to recall any words spoken during the task. Those who had performed the task synchronously no longer showed the self-memory advantage (better able to remember items that were self-produced).
VonZimmerman & Richardson (2016)	Verbal synchrony (100 secs). Adult participants (tested in groups of 23-34) read out word lists either in time with each other or not. They then played the tightrope game and performed a memory test.	Affiliation (self-report), joint action (tight rope game) and memory (test). Those in the synchronous condition reported more affiliation for their co-actors, and enhanced memory of the word lists. While there were no group level differences for joint action performance, individual analysis suggested that those in the synchronous condition made quicker responses.
Valdesolo, Ouyang & Desteno (2010)	Rocking (90 secs). Adult participants (tested in pairs) rocked in rocking chairs in one condition synchronously side by side, in the other asynchronously back to back.	Affiliation (self-report) and joint action (completing a two-person maze). Participants who had rocked synchronously showed increased sensitivity to each other's movements and completed the maze task more quickly than those who had rocked asynchronously. Those who had rocked synchronously also reported higher levels of social affiliation but did this did not predict success in the joint action task.
Lumsden, Miles & Macrae (2014)	Arm curls (2 mins). Adult participants (tested individually) performed either synchronous or asynchronous arm-curls, along with a video of another person.	Affiliation, overlap and self-esteem (self-reports). Those in the synchronous condition reported greater self-esteem than those in the asynchronous condition, and greater overlap with the other, but not affiliation.

Article	Entrainment Method	DV & Results
Fessler and Holbrook (2014)	Walking (not reported). Participants (tested individually) walked with a confederate either in synchrony or at a natural pace. They then estimated the size and strength of criminals from mug shots.	Affiliation, overlap and formidability (self-reports). Those in the synchrony condition reported greater social-bonding with the confederate, and they also rated the mug shots of criminals as belonging to less formidable (smaller and less muscular) individuals. Social-bonding was shown not to mediate formidability ratings.
Fessler and Holbrook (2016) Exp. 1 & 2	Heard walking (not reported). Participants (tested individually) were asked to judge the fighting capacity of groups of soldiers based on an audio recording of their footsteps, which were either synchronous or not.	Perceived formidability, entitativity and affiliation (self-reports). Synchronised targets were judged as more formidable (larger and more muscular), more affiliative and more entitative than asynchronous targets. Formidability was found to be fully mediated by entitativity but not by affiliation.
Lakens (2010) Exp. 1,2,3 & 4	Watched waving (not reported). Participants (tested individually) watched videos of stick figures (which were a range of different sizes and colours) waving to either the same or different rhythms (ranging in closeness) and then rated them on entitativity. In Exp. 4, videos of women waving were used instead of stick figures.	Entitativity (self-report). Figures that were waving to the same rhythm were judged as more entitative than those waving at different rhythms. This was the case even if stick figures were rhythmically waving with different arms. This movement information was more important for entitativity judgements than size or colour of stick figures. Closeness in rhythms predicted entitativity. Identical results were seen when videos were people rather than stick figures.
Lakens and Stel (2011) Exp. 1	Watched waving (not reported). Participants (tested individually) watched videos of women waving either synchronously or asynchronously. They were then asked to rate the actors for rapport and entitativity.	Rapport and entitativity (self-reports). Those who were waving in synchrony were judged higher in rapport and entitativity. Mediation analyses suggest these effects were not independent of each other, though tests were unable to distinguish which was mediating which.
Lakens and Stel (2011) Exp. 2	Watched walking (11 secs). Participants (tested individually) watched videos of boys walking synchronously either because they were instructed to or did so spontaneously. They were then asked to rate the actors for rapport and entitativity.	Rapport and entitativity (self-reports). Those who were believed to be synchronising spontaneously were judged higher in rapport and entitativity. Mediation analyses suggest these effects were not independent of each other, though tests were unable to distinguish which was mediating which.
Miles, Nind & Macrae (2009) Exp. 1 & 2	Heard or watched walking (150 secs). Participants tested individually either viewed or heard synchronised walking at different phases then rated how much rapport they perceived there to be between walkers.	Perceived rapport (self-report). The highest rapport ratings were found after viewing or hearing in- and anti-phase synchrony compared with out-of-phase.
Fawcett & Tuncgenc (2017)	Watched coordinated movement (30 seconds). Children (aged 12-15 months, tested individually) watched a clip of three animal characters moving, the middle character moved synchronously with one of the characters and asynchronously with the other. Following the movement, the middle character leaned towards one of the other two.	Looking time (secs). Looking measures showed 15-month-old infants expected affiliation towards those characters who had moved synchronously but not those who had moved asynchronously (similar effects were not seen in 12-month old infants).

Article	Entrainment Method	DV & Results
Miles, Lumsden, Richardson & Macrae (2011)	Arm curls (60 secs). Participants (tested individually), using the minimal group paradigm, were assigned to either the same or different groups as a confederate and asked them to perform arm curls.	Liking (self-report) and coupling (proportion of time in-phase). More time was spent performing arm curls in-phase by out-group pairs than in-group pairs. Authors suggest this is because IPE acts as a means to cultivate a shared group amongst co-actors who do not already view each other as common group member. Liking didn't differ between conditions
Tuncgenc & Cohen (2016b)	Musical movement task (3 minutes). Children (aged 7-11 years, tested in groups of 6) were assigned to groups using the minimal group paradigm three children in each minimally formed group per session. They then performed a whole-body movement task in time to music, either coordinating or not with members of the same or different group.	Group bonding, overlap (self-reports) and social closeness (behavioural spatial proximity task). Entrainment increased group bonding amongst out-group members on both self-report and behavioural measures, while no such increase was seen amongst co-actors who were already identified as common group members. Following synchronous movement, out-group bonding reached the same levels as in-group bonding. Children in the non-synchronous condition were significantly more likely to choose their own group island.
Good, Choma & Ruso (2017)	Tapping (3 mins). Participants (tested in groups of 6) divided into two groups using a minimal group paradigm and performed bonding exercises in their groups of 3; they were then brought back together into groups of 6. They then performed a tapping task where everyone tapped asynchronously, each smaller group tapped in sync (intra-group), or everyone taped in synchrony together (inter-group).	Social categorisation (self-report), cooperation (group modified public goods game). After tapping with their own group, individuals were more likely to donate to that group than they were in other conditions. If they had tapped with everyone, they were more likely to donate to the whole group than those in other conditions. Equally, those who tapped in asynchrony were most likely to rate their experimental cohort as six individuals, those who tapped with their own group as two separate groups, and those who all tapped together as one group.
Pearce, Launay, Duijn, Rotkrch, David-Barrett & Dunbar (2016)	Singing (6 mins). Participants (in groups of 8 comprised of 2 teams of 4) from different fraternities sang in time with either members of the same or a different fraternity in either a competitive or a cooperative way. Connectivity to and overlap with the groups were assessed before and after the task. They then had to complete a competitive wall sit for as long as possible.	Closeness to group (self-report). Those in the competitive conditions held the wall sit for longer. People felt closer to the other fraternity members after both competitive and cooperative singing; however, they only felt closer to their own team after cooperative but not competitive singing. The authors hypothesised that cooperative singing can overcome social boundaries by connecting the members of different groups together.
Good & Ruso (2016)	Group singing (30 minutes). Children (aged 7-8, tested in groups of 16) took part in one of three activities at a summer camp: group singing, group art or competitive games.	Cooperation (prisoner's dilemma played in a randomly paired dyad). Children involved in group singing exhibited greater cooperation than those in group art tasks or competitive game play. The authors suggest that a shift in social categorisations mediates cooperation.

The pro-social effects of IPE

The most commonly explored psychological consequences of IPE are changes in pro-sociality, that is, voluntary actions that help or benefit others independently of the group they belong to (Eisenberg, Lennon, & Roth, 1986). The umbrella term 'pro-social' was originally constructed by social scientists to serve as an antonym for anti-social and was meant to cover a wide range of actions that benefit one or more people

besides oneself (Batson & Powell, 2003). For instance, within the domain of helping alone, behaviours can range from spontaneous helping (rescuing) to planned helping (giving social support) or doing something to help (volunteering) to giving something to help (donating), each of which themselves vary by context (i.e., donating spare change versus donating a kidney).

Variables that account for variance in one form of pro-social behaviour are unlikely to account for the same amount of variance in another form of pro-social behaviour or in another behavioural context (Levine, Martinez, Brase, & Sorenson, 1994; Omoto & Snyder, 1995). Thus, as argued by Batson and Powell (2003), rather than identifying specific predictors of pro-sociality that can account for the most variance, researchers should instead look to existing theories about psychological processes and use studies to illustrate how these processes enhance our understanding of pro-social behaviour. Thus, in this section, we explore how IPE has been shown to affect a wide range of pro-social behaviours by using 'pro-social' in the way it is commonly employed within the IPE literature, as an act that benefits others and has no foreseeable negative consequences.

Multiple experiments have shown that tapping in time with people can nurture rapport in ways not explained by the mere experience of synchrony, and that can only occur when people believe they are entraining with another person (Hove & Risen, 2009; Launay, Dean, & Bailes, 2014). These findings show how a simple entrainment task can affect how we perceive our interpersonal relationships and highlights how the social aspects of these tasks are critical for cultivating these effects. Both singing and tapping in time with people have also been shown to affect actual behaviours as well. Following IPE, participants make greater offers to help co-actors with a time-consuming task (Valdesolo & Desteno, 2011) and show more cooperation and trust on economic games (Anshel & Kipper, 1988; Launay, Dean, & Bailes, 2013). Greater cooperation amongst entrained people has even been found when such cooperation comes at a real financial sacrifice to those involved, which is partially mediated by feelings of being on the same team rather than social affiliation (Wiltermuth & Heath, 2009). This supports the social-identity explanation. Other studies have found greater cooperation on an economic game following synchronous chanting, where the only self-reported measure that correlated with cooperation was ratings of trust (Reddish et al., 2013).

All of the work previously described has only measured social bonding following IPE versus control tasks. The studies have only compared scores across groups, which means they cannot show actual changes in social bonding for individuals. The only work to look for actual changes in social bonding within individuals following an experimental IPE manipulation did not find any increase in affiliation or overlap following coordination, despite finding greater cooperation following IPE (Cross, Wilson, & Golonka, 2016). This finding suggests that at least in some cases the cooperative effects of entrainment can be promoted in the absence of accompanying changes in social bonding.

Imagined IPE has been shown to increase social affiliation amongst larger groups of 3-4 people, but this did not lead to an effect on cooperation (Cross et al., 2017). Here, an increase in participants viewing themselves less as unique individuals and more as part of a group after imagined IPE was shown to correlate with increases in social affiliation. This body of work suggests that increased social affiliation does not always lead to other pro-social effects (such as cooperation), and that de-individuation and entitativity might be potential mediators between IPE and social affiliation. This lends better support to the social-identity than the social-bonding explanation.

Other work also provides evidence that social bonding is not driving the relationship between IPE and pro-social behaviours. Lang, Bahna, Shaver, Reddish and Xygalatas (2017) showed that while overlap mediated liking after IPE, it does not mediate cooperation, again suggesting that IPE's effects on cooperation are independent of social bonding. The study suggests that IPE's effects on cooperation are independent of social bonding, but may be mediated by an increase in endorphins. It has been suggested that endorphin release following synchronous activity may be involved in group formation and maintenance, akin to its role in such in other primates following grooming (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2009). However, this is not unanimously supported (Tarr, Launay, & Dunbar, 2016). Other authors suggest that endorphin release may not apply to less strenuous types of coordination, such as tapping or singing (Cohen et al., 2009). While the role of endorphins in IPE's social effects remains unclear, more work has found that increased overlap following entrainment does not translate into greater cooperation on an economic

game (Tarr et al., 2016)**.** Furthermore, fieldwork has shown that increases in social bonding following group singing are more likely to be driven by collective (specific to a group relations and identities) rather than relational (specific to individual relations) factors (Pearce, Launay, MacCarron, & Dunbar, 2017). These findings, therefore, provide evidence for the social-identity over the social-bonding explanation.

Across two experiments, Reddish et al. (2013) provide some evidence that the pro-social effects of IPE might in some cases be dependent upon whether co-actors share a common goal to coordinate. In Experiment 1, a group goal was not strictly necessary for cultivating greater cooperation following IPE, but it did further increase it. A shared group goal was, however, necessary for greater overlap to be observed. While similarity measures did not predict cooperation, a measure of trust did. In Experiment 3, both synchrony and shared intentionality were crucial to foster greater cooperation. This time, measures of similarity, overlap and entitativity combined did significantly correlate with cooperation. This work suggests that IPE's ability to foster cooperation might in some cases be dependent upon co-actors having a group goal to coordinate, which is believed to be one of the ways in which individuals come to see each other as common group members (Hogg & Williams, 2000). In addition, this work provides further evidence that measures of social bonding are not always mediating the pro-social effects of IPE, but that in combination with measures of how tightly we perceive each other as a common group (entitativity) they may mediate other pro-social effects. Other work has also found greater hypothetical helping following coordination that is not related to social bonding. Hu, Hu, Li, Pan and Cheng (2017) found greater reported helping and shared intentionality, but not similarity, following coordinated tapping. In sum, these findings also favour the social-identity over the social-bonding explanation.

Some work suggests that a propensity towards fairness, as opposed to cooperation, might underlie why IPE encourages more pro-social decisions in economic games, at least amongst young (around 4 years old) children (Rabinowitch and Meltzoff, 2017a). The authors suggest that changing evaluations of peers (whereby individuals view co-actors as in-group members) could account for these findings, therefore supporting the social-identity explanation. Interestingly, the authors contrast the increase in generous behaviours found following both synchronous and asynchronous swinging with the cooperative behaviours measured in Rabinowitch and Meltzoff (2017b), which were only shown to increase following synchronous (not asynchronous) swinging. The authors discuss the possibility that cooperation (which relies on mutual understanding) may be particularly influenced by synchronous movement, as it allows a pair to increase their sensitivity to each other and adjust their behaviour. In contrast, generosity is more reflective of individual decision-making (as children made resource allocation decisions independent from their partner), and thus is affected by shared movement experiences in general.

As we have just seen, pro-social effects of entrainment have also been demonstrated in children as well as adults. Research on infants (Cirelli, Einarson, & Trainor, 2014; Cirelli, Wan, Spinelli, & Trainor et al., 2017) shows that at only 14 months they experience the pro-social effects of IPE when moved in time with a co-actor, showing significantly more helping behaviours. Following infancy, self-propelled actions are understood to signal animacy and intentions (Gergely & Csibra, 2003) and are more frequently imitated early in development (Elsner, 2007). Thus, research on children in early (4-6 years old; Kirschner and Tomasello, 2010; Tungenc & Cohen, 2016a) and late (8-9 years old; Rabinowitch & Knafo-Noam, 2015) childhood have used self-directed synchronous movement paradigms to show greater ratings of similarity, closeness cooperation and spontaneous helping amongst children. This indicates that beginning in infancy and extending throughout childhood, IPE consistently influences pro-social behaviours. Other developmental research on the social effects of IPE will be discussed in more detail in the following sections, focusing on generalisation of pro-sociality after IPE and how group identities affect this process.

While a great deal of work has found IPE can foster greater pro-sociality amongst children, not all work shares this conclusion (Kirschner & Ilari, 2013)**.** Recall too that other work has also failed to find greater cooperation amongst adults following actual (Tarr et al., 2016) and imagined (Cross et al., 2017) entrainment, despite seeing greater social bonding. While a great deal more published work has found more pro-social behaviour following IPE than work that has not, this may be in part be due to the null bias in publication (Ferguson & Heene, 2012). However, two recent meta analyses in this area (Rennung & Göritz, 2016; Mogan et al., 2017) solicited unpublished work to include in their analyses, and both showed

stable effects of IPE on behavioural and self-reported measures of pro-sociality. Furthermore, Mogan et al. (2017) addressed the issue of publication bias directly, and their analyses did not support the notion that the literature may be skewed by publication bias.

Interim summary of IPE's pro-social effects

It seems clear that IPE can affect not only our social affiliations (liking, similarity, rapport), but that it can more broadly influence our social behaviours (cooperation and helping behaviour) across a wide age range, and there is some evidence that this phenomenon might be related to changes in in-group dynamics. Can this range of pro-social effects be explained under the group-formation framework?

The creation of a common group identity amongst individuals is thought to lead to an increase in trust and helping behaviour among group members (De Cremer & Stouten, 2003; Nier, Gaertner, & Dovidio, 2001). Both adults and children show increased cooperation and helping towards in-groups (Fehr, Bernhard, & Rockenbach, 2008; McLeish & Oxoby, 2011). Even artificially created minimal groups lead people to exhibit such in-group favouritism (Ahmed, 2007). Minimal grouping can also have a positive effect on our social evaluations of group members (Locksley, Ortiz, & Hepburn, 1980). Therefore, to our knowledge, all of the pro-social effects of IPE reported can be explained as a by-product of it cultivating a common group mentality amongst co-actors.

While in some cases (Reddish et al., 2013, Exp 3) greater social bonding is related to greater cooperation (though only when combined with measures of entitativity), in other cases (Cross et al., 2016; Lang et al., 2017; Reddish et al., 2013, Exp 1), the cooperative effects of IPE can be fostered without accompanying increases in social bonding. Increases in social bonding do not always bring about greater cooperation (Cross et al., 2017; Tarr et al., 2016). This pattern of evidence does not situate social bonding as strictly necessary for IPE to cultivate other pro-social effects. Work exploring the importance of group goals suggests that shared intentionality may be important for these effects (Reddish et al., 2013), again favouring the social-identity explanation. It seems the weight of the evidence reviewed so far favours the social-identity explanation, which situates social bonding as an effect rather than a crucial part of the mechanism. Furthermore, measures of feeling on the same team, entitativity, and de-individuation have been shown to correlate with or mediate other pro-social effects (Cross et al., 2017; Reddish et al., 2013; Wiltermuth & Heath, 2009).

What is conceived of as pro-social behaviour is subjective and context-dependent. Stopping to help an injured person would be widely considered pro-social, but one group trying to rid the world of people they perceive as troublesome might be considered pro-social by some but not by others. Therefore, pro-sociality could be further split into pro-group (situated within the context of one particular group) versus pro-society (or what is perceived as pro-social independent of particular groups). All of the work we have reviewed so far concerns the ways in which individuals feel and act towards people they have entrained with. Therefore, these effects could be considered as pro-group rather than pro-society. We will now explore work concerning how IPE impacts the ways we feel and our actions towards those not involved in the entrainment episode. These findings are particularly important. Specifically, if the social effects of IPE are driven by co-actors adopting a common group, then more positive behaviours following IPE should only be seen towards co-actors, and not towards people who weren't involved.

Do the pro-social effects of IPE generalise beyond co-actors?

Some work has shown that greater pro-sociality following IPE is restricted to co-actors. For example, Kokal et al. (2011) found that participants only helped an experimenter they believed had been drumming in synchrony with them (as opposed to one they believed had drummed with asynchronously). Other work shows that greater social bonding following IPE was only seen towards those who were involved in it, and not more generally towards those not taking part (Tarr, Launay, Cohen, & Dunbar, 2015). Such restricted pro-sociality has also been shown in young infants, who showed more spontaneous helping following synchronous bouncing, but only towards those that the infants had bounced in time with and not those

who had merely observed (Cirelli, Wan, & Trainor, 2014). These works suggest that the pro-social effects of IPE are indeed restricted to co-actors, and do not stretch more generally to those not engaged in the entrainment episode.

However, not all work supports this conclusion. Experiments by Reddish et al. (2014) suggest that the pro-social effects of IPE can generalise to those not involved in the entrainment episode. One experiment showed that moving in synchrony increased helping behaviour not only towards co-actors, but also towards people not present for the movement task. Another experiment showed that those who had entrained donated significantly more resources to another group, who had instead completed a puzzle task. This work suggests that IPE fosters pro-sociality not only towards those we have entrained with, but also towards those not present during the task. The authors advocate that IPE fosters a generalised pro-sociality that extends to those outside of the entrainment episode.

Other work suggests that IPE increases pro-sociality towards people who were not involved in the movement task, even if they are categorised as out-group members (Reddish et al., 2016). In this study people were primed to perceive their co-actors as common group members, those who had entrained were no more likely to help an in-group member, but were more likely to offer to help an out-group member. No differences in the amount of time offered were found, but the study did not report whether participants actually followed through with their offer to help. Mediation analysis showed that entitativity mediated social bonding, though social bonding was shown not to mediate helping. Results also suggest that entrainment does not increase identification with a pre-existing group, although this is not surprising as participants were already primed to think of themselves as in-group members before the entrainment task. However, another study suggests that the pro-social effects of IPE only extend to those who are viewed as affiliates of co-actors (Cirelli, Wan, & Trainor, 2016). Here, greater helping in children following IPE was only demonstrated towards a person shown to have an affiliative relationship with the entrained co-actor.

The findings of Reddish et al. (2014) suggesting generalised pro-sociality, and Reddish et al. (2016) suggesting that this even extends to out-group members, are at odds with the group-formation framework. If entrainment fosters pro-sociality by cultivating a common group mentality amongst co-actors, then such effects would only be expected towards that group, not stretching to people not involved. However, not all research supports the notion of generalised pro-sociality. Kokal et al. (2011), Cirelli et al. (2014) and Tarr et al. (2015) show that pro-social effects are restricted to people we actually entrain with. Furthermore, Wiltermuth (2012a) shows that other 'non pro-social' effects, such as increased conformity, are also restricted to co-actors. Cirelli et al. (2016) found that effects only generalise to people who are viewed as affiliates of co-actors (which is consistent with the group-formation framework). So, what might explain the difference between works that show generalised effects and works that show restricted effects?

One crucial difference between works that do and do not support generalisation is whether non-actors are present for the entrainment or not. In Reddish et al. (2014), which supports generalisation, greater pro-sociality was shown towards people who were not present for the entrainment. However, in Kokal et al. (2011) and Cirelli et al. (2014), which do not support generalisation, non-actors were present for, but not participating in, the coordination task. In Tarr et al. (2015) and Reddish et al. (2016), the non-actor was a hypothetical person. This suggests that whether or not one is present for the coordination may be a crucial aspect regarding the generalisation of pro-sociality. It may be that we are particularly likely to classify other people as separate from the emerging collective if these others were present for but not involved in the entrainment episode.

Secondly, it may be the case that the results of Reddish et al. (2014) may have been affected by decreased generalised pro-sociality following the control tasks. Observing others engage in IPE and performing a jigsaw puzzle in silence (the control tasks employed) may have individuated participants and reduced cooperation, which accounted for differences in generalised cooperation seen between control and experimental conditions. Cross et al. (2017) provide some evidence that individuating control conditions may be capable of decreasing cooperation amongst an experimental cohort. Sitting and watching other people engage in a joint action task and completing a jigsaw while not being allowed to speak may well foster greater feelings of independence and/or individuation in participants. This could lead to *decreased* pro-sociality in these conditions, which would account for the observed differences in cooperation. This

explanation is supported by the fact that no differences in pro-sociality were found between asynchronous and synchronous movement conditions. Here, significant differences were only found between those who performed the task synchronously and those just watching the task being performed by others.

The group-formation framework also highlights an alternative explanation for work supposedly supporting generalised pro-sociality: in-group impression management. In-group impression management suggests we are more likely to share resources more fairly with others (and more likely to cooperate with and help others; Reis & Gruzen, 1976) if we believe we are being observed by an in-group member (Engelmann, Over, Herrman, & Tomasello, 2013). If engaging in IPE does indeed foster a common group mentality amongst co-actors, then this may explain why monetary resources were shared out more evenly by those who had previously entrained. It is also worth noting that those who entrained in Reddish et al. (2014; 2016) did not donate more to the other group, but actually shared the money out more equally between groups. Recall that Rabinowitch and Meltzoff (2017a) also suggest that this effect has more to do with fairness than cooperation. Furthermore, only about half of the people who offered to help in Reddish et al. (2014) actually followed through with their offer (no details were reported for how many followed through from given conditions). Similarly, in Reddish et al. (2016) out-group offers of help following IPE rose to the same level as in-group helping offers, though there were no differences in the amount of time donated, and no details were given on the proportion of people that followed through with their offer to help. Therefore, impression management may be a more plausible explanation than generalised pro-sociality for these findings, especially considering that Reddish et al. (2014) shows relatively few of the people who offer to help in this task actually do so.

In summary, more work suggests that the effects of IPE are restricted to those who actually took part in the entrainment episode, and their affiliates (Cirelli et al., 2014; 2015; Kokal et al., 2011; Tarr et al., 2015) compared with those that suggest generalised effects (Reddish et al., 2014; 2016). Further evidence exists to support alternative explanations for the findings of Reddish et al. (2014; 2016), and the authors' explanation (that IPE fosters generalised pro-sociality) is not well supported in this literature. For example, as we shall illustrate next, IPE far from fostering generalised pro-sociality, can also foster what could be considered anti-social behaviour towards people not involved in the entrainment episode. IPE's effects are considerably more diverse and complicated than simply fostering pro-sociality towards people we have entrained with. So, can the group-formation framework also explain why we see this wider landscape of effects?

Beyond pro-social effects

The social consequences of IPE are not all pro-social; it has also been shown to have a 'darker side'. Research has shown we are more willing to obey an order to kill bugs and kill more of them (Wiltermuth, 2012a), or to expose strangers to loud, aggressive noise blasts, if the requests come from people we have entrained with (Wiltermuth, 2012b) if the requests come from people we have entrained with. This effect was shown to be partially but not directly mediated by social bonding (Wiltermuth, 2012b). These findings highlight that IPE can promote behaviours that could be considered quite anti-social (to those outside of the group at least). Such findings suggest that IPE does not foster generalised pro-sociality, and furthermore, they can be explained by the group-formation framework (i.e., they are also social consequences that follow group formation and identification).

Self-categorisation theory (Turner et al., 1987) proposes that in-group members are more influential to other in-group members, and Postmes, Spears and Lea (2000) showed that people tend to conform to the conventions of a group once it is formed. Benisom and Bodner (2011) argue that people lose their sense of individuality, responsibility and control when in groups, leaving them more suggestible to the ideology of the group. The authors report field research showing that synchronous chanting at football games is significantly linked to greater aggression towards the opposing team's fans. In conclusion, the 'darker side' of IPE's effects can be explained by the group-formation framework, and some of this work suggests that these effects are related to but not directly mediated by social bonding. IPE's consequences for our social world span beyond just promoting pro-sociality, obedience and conformity; it can also affect our attention

towards and memories of co-actors. So, can these also be accounted for by the group-formation framework?

Memory and attention

IPE has been shown to affect our attention to and memory of people we entrain with. Entraining with someone has been shown to increase recognition of co-actors (Macrae et al., 2008) and to enhance the amount of attention we pay to co-actors and our memories of them (Woolhouse & Lai, 2014; Woolhouse, Tidar, & Cross, 2016). Indeed, memory and attention may underlie the process by which we come to think of ourselves and co-actors in common group terms.

Martiny-Huenger, Gollwitzer and Oettingen (2014) have shown that paying increased attention to in-groups facilitates intergroup bias. They argue that paying increased attention to people due to the constraints of goal-directed tasks systematically influences group bias. This increased memory for co-actors may, therefore, be a crucial part of the mechanism by which IPE induces progroup thinking and behaviour. Bernstein, Young, and Hugenberg (2007) showed that categorising people as in-group members facilitates improved recognition of them, even if these groupings are formed under minimal circumstances (such as an arbitrary choice, coin toss, or art preference). The authors later showed that this is due to a deeper encoding of in-group targets (Young, Bernstein, & Hugenberg, 2010). In-group targets are remembered better than out-group targets, and this can explain the superior memory for co-actors seen following entrainment.

IPE also modulates how we store memories. The self-reference effect shows that people are better at storing and recalling information pertaining to the self than they are for information pertaining to others (Rogers, Kuiper, & Kirker, 1977). This self-memory advantage has been shown to disappear following IPE (Miles, Nind, Henderson, & Macrae, 2010), with people becoming just as good at recalling items generated by previously coordinated co-actors as items that were self-generated. Miles et al. (2010) suggest that participants were blurring the overlap between self and other. However, similar group-reference effects have also been shown (Johnson, Gadon, Carlson, Southwick, Faith, & Chalfin, 2002), and these indicate that people are better at storing and recalling information about a group they belong to. This effect can, therefore, be explained by the group-formation framework. There are two plausible competing explanations for these memory effects: 1) IPE leads to a blurring of the overlap between the self and other, where an individual essentially begins to represent the other as part of or an extension of the self; 2) IPE leads an individual to think of themselves and the other in de-individualised and more interpersonal terms. So, which of these explanations is better placed to deal with these findings?

The argument that IPE leads an individual to blur lines of agency between actions they and their co-actor executed makes sense for certain IPE paradigms, where two individuals are making complementary movements in direct view of one another. However, this explanation seems less plausible for IPE involving larger groups without direct visual information of each other's movements, for groups where co-actors are coordinating different movements in reciprocal ways, or for imagined IPE. Indeed, many of the ways we entrain both in these lab paradigms (i.e., Cirelli et al., 2014; Cross et al., 2016; Kokal et al., 2011; Rabinowitch & Meltzoff, 2017; Reddish et al., 2013; von Zimmerman & Richardson, 2016) and in real life (i.e., dancing in a group, military drill, playing music in an orchestra) bear more in common with the latter type of IPE than the former. In these cases, it seems less plausible that co-actors would be blurring the overlap between the agency of their own and their co-actors' movements. In these cases at least, it seems more likely that IPE is deindividuating individuals and blurring group rather than self-other lines.

This is not to say that blurring of self-other overlap never occurs. In some cases (for example Soliman, Fegurson, Desheimer, & Glenberg, 2015), joint action may indeed blur overlap between the self and the other, and this may feed back into the mechanistic account of how IPE has the effects it does. However, in at least some cases, evidence suggests that IPE has its effects in the absence of overlap blurring (Cross et al., 2016; Fessler & Holbrook., 2014; Lang et al., 2017; Reddish et al., 2013; 2016; Tarr et al., 2016). Therefore, the social-identity explanation emerges as a better-situated account for these findings than the social-bonding explanation.

Joint action

Engaging in IPE can also affect how well we perform unrelated joint actions. Verbal entrainment in large groups enhances joint action performance, memory for co-actors and affiliation (von Zimmerman & Richardson, 2016). Synchronous rocking has also been shown to lead to greater sensitivity to each movement and faster completion of puzzle tasks (Valdesolo, Ouyang & Desteno, 2010). As we have already seen, similar effects have also been shown in young children (Rabinowitch & Meltzoff, 2017b), indicating that these effects can be seen at an early age. Improved joint action makes sense under the group-formation framework. Dötsch and Schubö (2015) have found that people show more cooperative movement patterns during joint action tasks when they are performing them with people they believe to be members of the same group. Indeed, the shared identity among individuals performing a task should naturally improve their coordination, cohesion, and efficiency towards a goal (if there is one). In other words, when *we* are doing this, the '*we*' provides a unifying agency similar to the '*I*' (that is, just as I am doing this, the collective is doing this). Indeed Iani, Anelli, Nicoletti, Arcuri and Rubichi (2011) suggest that when co-acting individuals perform joint action in a social context, perceiving positive interdependence between each other paves the way to shared group representations. Von Zimmerman and Richardson (2016) also propose this to be an underlying mechanism for IPE's social effects, favouring the social-identity explanation.

Self-other evaluations and observer effects

Moving in time with people can also have positive effects on people's self-esteem (Lumsden, Miles, & Macrae, 2014). This too could be seen as a by-product of the formation or increased salience of a common group identity. Abrams and Hogg (1988) propose that psychological group identification leads to elevated self-esteem, as it allows a more positively evaluated social identity to be constructed. Building upon McNeill's (1995) ideas that IPE increases in-group cooperation and out-group competition and aggression, entraining with people has been shown to lead individuals to rate a mug shot of a purported criminal as smaller and less muscular (Fessler and Holbrook, 2014). Only coordination (not overlap or affiliation) was shown to predict perceived formidability (measured by how large and muscular an agent is perceived to be), suggesting these effects were not mediated by social bonding. One need not even engage in IPE to feel its effects; just observing others coordinating affects our social categorisations and perceptions is sufficient. Observing others entrain can lead to us perceiving them as more formidable (Fessler and Holbrook, 2016). Here formidability was found to be mediated by entitativity and not affiliation. These findings, therefore, favour the social-identity over the social-bonding explanation.

A series of experiments looking at how observing synchrony affects our social perceptions highlights how movement synchrony might be linked to the emergence of social units (Lakens, 2010; Lakens & Stel, 2011). These studies showed that both stick figures and actual people were perceived as higher in entitativity after waving in synchrony compared with waving out of synchrony. The more in time they were perceived to be waving, the higher the judgments of entitativity between them. Similar effects have been shown using visual and auditory information of co-walkers' footsteps (Miles, Nind, & Macrae, 2009). These effects have also been found in children as young as 15 months. Looking measures showed that infants expected affiliation towards characters who had moved synchronously but not those who had moved asynchronously (Fawcett & Tungenc, 2017). This suggests that from an early age, infants are perceiving affiliation amongst those they see coordinating.

These studies highlight how watching people move together in time fosters the appearance of rapport, unity, entitativity, affiliation and formidability between them, leading observers to view the rhythmically coordinated co-actors as a more tightly knit group. This demonstrates how IPE is intimately tied to group dynamics, even from the outside. In other words, individuals observed entraining are more likely to be viewed in interdependent (group) than independent (individual) terms. This suggests that IPE is indeed intertwined with how we view people in independent compared with interdependent terms, which is consistent with the group-formation framework of IPE's socioemotional effects. Furthermore, as we have seen, these findings particularly favour the social-identity over the social-bonding explanations.

Summary of IPE's social effects

In summary, IPE can affect not only our social evaluations and pro-social behaviours, but also conformity, obedience, memory, attention and our ability to perform unrelated joint actions. As we have highlighted throughout this manuscript, this wide range of effects are all also typical group effects, which can all result from the formation/recognition of a common collective identity. The group-formation framework, therefore, provides a parsimonious yet comprehensive account of the rich tapestry of effects that entrainment has on our social cognition and behaviours. It is worth noting that the relationship between IPE's social effects and group identity is not unidirectional. Whether we are entraining with co-actors with whom we already share an identity (e.g., a common nationality) or not also affects both to what degree we coordinate and the social consequences of that coordination. We now turn to the literature assessing how already formed groups (i.e., existing prior to entrainment) affects IPE and its social effects.

How group identities affect IPE and its social effects

Whether we perceive somebody as part of a common group affects the degree to which we coordinate with them. More spontaneous in-phase coordination is seen when people are performing a movement task with members of a different minimally created social group than with members of the same group (Miles, Lumsden, Richardson, & Macrae, 2011). Miles et al. (2011) suggest that IPE serves to reduce social distance and intergroup differences amongst co-actors, which explains why more coordination is seen with out-group members than in-group members. The additional coordination seen towards out-group members is thought to be due to IPE being a means to cultivate a shared collective identity with co-actors, which was unnecessary when coordinating with an in-group member (Miles et al., 2011). The above work highlights that group membership is intertwined with IPE affecting how tightly people are temporally coupled in a coordination task.

More recently, work has begun to look at how the social effects of IPE might actually be modulated by group formation. Tuncgenc and Cohen (2016b) show that in children, IPE only reduces social distance and increases bonding between members of different minimally created social groups. Here, IPE increased social bonding amongst out-group members on both self-reported and behavioural measures, while no such increase was seen amongst co-actors who were already identified as common or in- group members. Research has also explored how IPE influences social categorisation and cooperation across group boundaries in children (Good et al., 2017). This work shows that after entraining, people were more likely to cooperate with whichever group they had entrained with, crucially, people were more likely to rate their cohort as: 1) individuals if there was no entrainment; 2) two groups if they entrained with one group but not the other; 3) one group if everyone entrained together.

Similar findings have also been shown in adult samples with naturally created groups (Pearce, Launay, Duijn, David-Barrett, & Dunbar, 2016), where participants from different university fraternities were made to sing in time with either members of the same or a different fraternity. Results showed that the increase in closeness to the group was greater when people were singing with people from different fraternities. Other work has also shown that group singing cultivates greater cooperation in a diverse group of children than group art tasks or competitive gameplay (Good & Ruso, 2016). The authors of both of these studies suggest that group singing cultivated a collective identity, which may mediate other effects.

The above findings are of great significance for our understanding of how IPE affects social behaviour. If IPE's social effects are a consequence of the formation of a common group amongst co-actors, greater increases in these measures following IPE should be seen amongst co-actors who did not already share a collective identity. This is because co-actors who are already perceived as in-group members do not have as much to gain from the formation of a shared collective identity. Not only are these findings supportive of the group-formation framework proposed here, but they are more consistent with the social-identity than the social-bonding explanation. If these effects were mediated by social bonding then we should see more cooperation following IPE with in-groups rather than out-groups, since in-groups would presumably

have greater social affiliation and overlap to begin with. However, if the pro-group effects of IPE are driven by the kinds of re-categorisation that Good et al. (2017) suggest, greater effects should be observed when people are entraining with people they do not already share a common group identity with. Therefore, we conclude that these findings favour the social-identity over the social-bonding explanation. We will now briefly re-cap the evidence for each subclass of explanation.

Summarising the evidence so far and moving forward

This work highlights how the group-formation framework is well suited to account for the wide range of socio-emotional effects of IPE. It provides a unifying framework to interpret what appears to be a heterogeneous spectrum of IPE's outcomes and offers a parsimonious account of this landscape. This idea is consistent with theories of the adaptive advantages IPE once offered our ancestors. The wide plethora of effects that have been shown to follow IPE are also consequences of group formation (i.e., in/out -group effects), and evidence of how pre-existing group identities affect both IPE and its effects are in line with the group-formation framework. We therefore suggest that pro-group thinking and behaviour might be a more useful way to summarise IPE's social effects than pro-social thinking and behaviour.

While the body of literature on the social effects of IPE to date is largely consistent with a group-formation framework, more work is still needed to understand whom these effects are directed towards. If effects are consistently shown to generalise beyond those we coordinate with, especially to those who are separate and distinct from the emerging group, then this evidence would falsify the explanation offered here. In particular, future work may wish to focus on whether the same effects are seen towards absent versus present observers not engaged in IPE, as well as those shown to be part of a different, opposing or competing group. Future work could also explore if other in/out-group effects are a function of IPE. For example, in/out-groups have been shown to differ in perceived variance. People have been shown to judge common group members as being more variant than those who are members of other groups (Haslam, Oakes, & Turner, 1996). Perceived variance judgments could be a useful tool in investigating whether people do indeed view those they have entrained with as common group members. Establishing the perceived variance amongst co-actors following IPE could help support or falsify the claim that IPE is indeed modulated by how entrained individuals perceive themselves and their co-actors in independent/interdependent terms.

This review also evaluated the support for the social-identity and the social-bonding explanations of how IPE might lead to a common group mentality amongst co-actors. Table 2 summarises all the studies that test either explanation, and details whether or not each of the explanations were supported. While outside the scope of this work, it is worth noting that to unravel the relationship between IPE and its social consequences, we need a better understanding of the neuroendocrine as well as cognitive mechanisms underlying IPE's pro-group thinking and behaviour. For a discussion of the potential neuroendocrine mechanisms see Tarr, Launay and Dunbar (2014) and Shamay-Tsoory, Saporta, Marton-Alper and Gvirts (2019).

The social-bonding explanation is not well supported in the literature reviewed here. As Table 2 illustrates, many studies have found no effect of IPE on self-other overlap as measured by the IOS (Cross et al., 2016; Fessler & Holbrook, 2014; Lang et al., 2017; Reddish et al., 2013; 2016), despite finding other pro-group effects. Similarly, Tarr et al. (2016) found greater overlap after IPE that did not lead to greater cooperation. In contrast, the only studies to find evidence for a mediating role of overlap showed that IOS combined with social affiliation partially but not directly mediated IPE's effects on obedience and conformity (Wiltermuth, 2012b), and that overlap combined with affiliation and entitativity mediated IPE's effects on cooperation (Reddish et al., 2013). These results suggest that on its own, self-other overlap is not well supported as a mediator of IPE's other social effects. However, it should be noted that the IOS could be described as more a measure of perceived similarity rather than blurred agency, as participants self-reported the perceived distance between representations of the self and the other. More implicit tests, such as the Automatic Imitation task (Brass, Beckering, & Prinz, 2001), may be more accurate in assessing blurred agency.

Table 2. A summary of all studies supporting or refuting either explanation.

Article	Explanation supported	Relevant finding
Wiltermuth & Heath (2009)	SB - / SI +	Only feelings of being on the same team (not similarity) mediated cooperation.
Reddish et al. (2013)	SB - / SI -	None of affiliation, overlap, or entitativity correlated with cooperative behaviour.
Cross et al. (2016)	SB -	No changes in affiliation or overlap, despite greater cooperation.
Cross et al. (2017)	SB - SB - / SI +	Exp. 1: Changes in affiliation, which did not lead to changes in cooperation. Exp. 2: As above but also changes in feeling like a group member, which correlated with affiliation.
Lang et al. (2017)	SB -	Overlap mediated liking, but liking did not mediate trust, which was mediated by EOS activation (pain threshold).
Tarr et al. (2016)	SB -	Greater social bonding did not translate to greater trust.
Pearce et al. (2017)	SB - / SI +	Greater and faster bonding occurred at a group than at an individual level.
Reddish et al. (2013)	SB - / SI − SB + / SI +	Exp. 1: None of affiliation, overlap, or entitativity corelated with greater cooperation. Exp. 3: Similarity, overlap, and entitativity combined significantly correlated with cooperation.
Hu et al. (2017)	SB -	Greater reported helping and shared intentionality but not similarity.
Reddish et al. (2014).	SB - SB - / SI -	Exp. 1: Greater helping despite no changes in social bonding. Exp. 2: Greater helping despite no changes in social bonding or entitativity.
Reddish et al. (2016)	SB - / SI +	Entitativity mediated social bonding, though social bonding did not mediate helping.
Wiltermuth (2012b)	SB +	Social bonding mediated compliance.
Valdesolo et al. (2010)	SB -	Social affiliation did not predict success in the joint action task.
Fessler & Holbrook (2014)	SB -	Social bonding did not mediate formidability ratings.
Fessler & Holbrook (2016)	SB - / SI +	Formidability was mediated by entitativity but not affiliation.
Tuncgenc & Cohen (2016b)	SB - / SI +	Group bonding increased only amongst out-group members; no increase amongst in-group members.
Good et al. (2017)	SI +	More likely to see co-actors as common group members and show more favouritism to them.
Pearce et al. (2016)	SI +	Bonding effects are stronger amongst out-group members than amongst in-group members.

In relation to social affiliation, Cross et al. (2016) also found no change in affiliation scores within pairs following IPE, despite seeing greater cooperation compared with controls. Cross et al. (2017) found significant increases in affiliation amongst larger groups following imagined IPE, which did not translate into greater cooperation. Similarly, Pearce et al. (2017) showed that greater social bonding following IPE did not result in greater trust. Lang et al. (2017), Fessler and Holbrook (2014; 2016), Hu et al. (2017), Reddish et al. (2013; 2014; 2016) and Valdesolo et al. (2010) also provided evidence that measures of social affiliation are not always mediating IPE's other pro-group effects. There are therefore many more experimental examples of finding IPE's social effects in the absence of social bonding or vice-versa, and examples of social bonding not mediating other effects. In fact, only two studies support this explanation: Wiltermuth (2012b) showing social bonding partially mediates compliance, and Reddish et al. (2013) showing social bonding combined with entitativity partially mediates cooperation.

Social bonding, therefore, does not appear to be a strictly necessary part of the process by which IPE typically promotes other effects. However, it may contribute to other effects by further strengthening a

group mentality between co-actors, and in turn bolstering entrainment's social consequences under some circumstances (as has been suggested by Pearce et al., 2017). Under what circumstances social bonding has this bolstering effect is currently unclear. There are a plethora of reasons why in some experiments IPE may increase social bonding but not in others. For example, in the studies reviewed here, group size differs from 2 to 20+, in some cases co-actors are strangers and in others they know each other, entrainment time differs from 120 seconds to 60 minutes, and entrainment tasks can involve finger or foot tapping, drumming, marching, singing, or even waving cups and singing to the national anthem of a neighbouring country. Even within given studies, these experimental entrainment tasks can be compared with anti-phase or asynchronous versions of the same task, doing the task alone, watching others perform the task, performing completely different tasks such as completing jigsaw puzzles, or watching movies. Given the substantial variation in these elements, no clear pattern amongst findings emerge. The vast majority of studies only report averages between-group differences in social bonding, as opposed to actual within-individual changes in this measure, and this makes it difficult to identify what accounts for the difference in the findings of social-bonding changes as a result of IPE.

Future work should aim to try and untangle the conditions under which IPE increases social bonding, by taking measurements before and after different IPE manipulations and by investigating factors such as varying group size and co-actor familiarity. While there is some support for an increase in social bonding indirectly mediating IPE's pro-group effects (Reddish et al., 2013; Wiltermuth, 2012b), many more studies show that IPE's social effects are seen in the absence of social bonding, and that social bonding does not cultivate or mediate other effects (Cross et. al 2016; 2017; Fesslet & Holbrook, 2014; 2016; Hu et al., 2017; Lang et al., 2017; Pearce et al., 2017; Reddish et al., 2013; 2014; 2016; Tarr et al., 2016; Wiltermuth & Heath, 2009; Valdesolo et al., 2010). This inconsistency suggests that social bonding is not a crucial part of the mechanism in question.

There is a growing body of work suggesting that the social and psychological consequences of IPE may be due to changes in how co-actors view themselves and each other in individual versus common group terms (Cross et al., 2017; Fessler & Holbrook, 2016; Good et al., 2017; Reddish et al., 2013; 2016; Pearce et al., 2017; Wiltermuth & Heath, 2009). Research has shown that IPE's social effects may be mediated by greater entitativity (Fessler & Holbrook, 2016; Reddish et al., 2013; 2016 Wiltermuth & Heath, 2009;) and increases in de-individuation (Cross et al., 2017), though this does not occur in all cases (Reddish et al., 2013; 2014). Other work has shown that effects are stronger and more consistent when people are entraining with people they do not already view as common group members, which better supports the social-identity than the social-bonding explanation (Good et al., 2017; Pearce et al., 2016; Tungenc & Cohen, 2016). A recent study by Cross, Turgeon and Atherton (2019) also shows that IPE's effects on cooperation are only seen when people are entraining with members of different socio-culturally significant groups (different university and nationality), but not members of the same group (same university and nationality). Pearce et al. (2017) also provide evidence that the social effects of IPE are more likely linked to collective, group-level relations than individual ones. Furthermore, Lakens (2010), Lakens and Stel (2011) and Fessler and Holbrook (2016) have all shown that those who move in time together are viewed by observers in more interdependent than independent terms.

Together, the above results suggest that a change from viewing oneself and our co-actors in more interdependent (group) rather than independent (individual) terms may be a potential mechanism underlying the effects of IPE. This is further supported within the wider social coordination literature; changes in salient self-construal from one of independence to interdependence have also been shown to mediate the relationship between mimicry and its social effects (Ashton James, Van Baaren, Chartrand, Decety, & Karremans, 2007). As both mimicry and IPE are forms of social coordination that produce similar social outcomes (Chartrand & Bargh, 1999; Vicaria & Dickens, 2016), it is quite possible that, as with mimicry, IPE's social effects depend upon entrained individuals viewing their self-construal in more interdependent terms.

Future work should further test whether and how constructs like de-individuation, entitativity, and changes in self-construal might mediate the social effects of entrainment. Exploring how individuals construct their own identity following entrainment and how this relates to other socio-emotional factors may

prove another fruitful avenue of exploration in this field. If the group-formation framework is supported, a greater degree of interdependent self-construal should be seen following IPE. Innovative ways to assess the saliency of self-construal, such as qualitative methodologies, should be explored.

Future research may also wish to explore the potential role of IPE in other group dynamics such as conflict resolution, prejudice and stereotyping. Webb, Rossignac-Milon and Higgins (2017) recently put forward an argument for how IPE could positively impact conflict resolution. Indeed, satisfied couples show a higher level of interactional synchrony than dissatisfied couples during communication (Julien, Brault, Chartrand, & Begin, 2000). In-phase bodily synchronisation significantly decreases during argumentative interactions (Paxton & Dale, 2013). When we coordinate our speech rates with interlocutors, we are more likely to cooperate with one another (Manson, Byrant, Gervais, & Kline, 2013). What's more, the extent of non-verbal synchrony has even been shown to be a good predictor of positive therapy outcomes (Ramseyer & Tschacher, 2011). Given this link between coordination, conflict and other group dynamics, coordination between individual members of polarised groups could help reduce prejudice and stereotypical attitudes towards outgroups (Atherton, Sebanz & Cross 2019).

In conclusion, there is consistent evidence that the social effects of IPE might be a consequence of it forming a common group mentality between co-actors. We have shown how this group-formation framework is consistent with the vast majority of findings in this literature, how it can guide our future exploration, and how it offers us a theoretical framework in which we can situate these findings. It is worth highlighting that while moving in time together might have a range of pro-group effects that can help bring people together, these may come at a price. Losing oneself in the crowd can lead to behaviours that are not part of an individual's ethical codes and moral values (e.g., aggressive acts towards members of other groups). This stems from the fact that acting for the benefit of one's group typically means acting against the interests of competitive groups. That is not to say that there is no significant adaptive value of group cohesion; after all, it has been a driving force in many chapters of human history (McNeill, 1995). With the steep rise of new platforms of social interactions transcending geographical and cultural borders, the psychological consequences of being together remains at the forefront of psychological research.

> "I believe that synchronous, coordinated song and movement were what created the strongest bonds between early humans or proto-humans and these allowed for the formation of larger living groups and eventually society as we know it" - Levitin (2008, p. 50)

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