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Sync to link: Endorphin-mediated synchrony effects on cooperation

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A B S T R A C T

Behavioural synchronization has been shown to facilitate social bonding and cooperation but the mechanisms through which such effects are attained are poorly understood. In the current study, participants interacted with a pre-recorded confederate who exhibited different rates of synchrony, and we investigated three mechanisms for the effects of synchrony on likeability and trusting behaviour: self-other overlap, perceived cooperation, and opioid system activation measured via pain threshold. We show that engaging in highly synchronous behaviour activates all three mechanisms, and that these mechanisms mediate the effects of synchrony on liking and investment in a Trust Game. Specifically, self-other overlap and perceived cooperation mediated the effects of synchrony on interpersonal liking, while behavioural trust was mediated only by change in pain threshold. These results suggest that there are multiple compatible pathways through which synchrony influences social attitudes, but endogenous opioid system activation, such as β-endorphin release, might be important in facilitating economic cooperation.

1. Introduction

Across cultures, people engage in collective activities that involve the matching of behaviour in time, such as music production and singing, dancing, and collective rituals (Hagen and Bryant, 2003Hagen & Bryant, 2003; Merker et al., 2009). It has long been speculated that such synchronous activities function to increase group cohesion (Durkheim, 1964; Marsh, Richardson, & Schmidt, 2009; McNeill, 1995), and experimental research has supported this conjecture: synchronous behaviour has been shown to facilitate rapport and interpersonal liking (Hove & Risen, 2009; Lang et al., 2016; Miles et al., 2009); entitativity (Lakens & Stel, 2011; Reddish et al., 2013); cooperation in economic games (Launay, Dean, & Bailes, 2013; Reddish, Bulbulia, & Fischer, 2014; Wiltermuth & Heath, 2009); and helping behaviour (Kokal, Engel, Kirschner, & Keysers, 2011; Valdesolo & Desteno, 2011). Despite this convergent evidence, the mechanisms mediating these effects are still poorly understood. Recently, two potential mechanism were proposed by Tarr and colleagues: one related to self-other overlap and one related to the endogenous opioid system (Tarr, Launay, & Dunbar, 2014; see also Mogan, Fischer, & Bulbulia, 2017).

The self-other overlap mechanism builds on the literature describing the tight integration of perception and action systems (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Gallese, Gernsbacher, Heyes, Hickok, & Iacoboni, 2011). Common neural encoding can be amplified by behavioural synchrony, which may, at some level of cognitive processing, lead to the blending of other-generated and self-generated behaviour (Paladino, Mazzurega, Pavani, & Schubert, 2010). Perceiving interaction partners as part of oneself may lead to feeling closer to them (Overy & Molnar-Szakacs, 2009), as shown by studies on synchronous movement and singing (Reddish et al., 2013; Weinstein et al., 2015). However, the evidence for overlap-mediated synchrony is mixed, with some studies failing to find a direct relationship (Cohen, Mundry, & Kirschner, 2013; Fischer, Callander, Reddish, & Bulbulia, 2013; Reddish et al., 2013; Wiltermuth & Heath, 2009).

The β-endorphin release hypothesis, on the other hand, places emphasis on the biochemical basis of human sociality, suggesting that synchrony leads to increased affiliative and socially rewarding behaviour because it activates the endogenous opioid system (Loseth, Ellingsen, & Leknes, 2014; Machin & Dunbar, 2011). β-endorphin neurotransmitters and related μ-opioid receptors (MOR) have been previously implicated to play an important role in mother-infant

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attachment, distress vocalization, and social grooming in rodents and non-human primates (Graves, Wallen, & Maestripieri, 2002; Kalin, Shelton, & Lynn, 1995; Moles, Kieffer, & D'Amato, 2004; Panksepp, Nelson, & Siviy, 1994). In human studies, however, a direct assessment of brain opioid levels from cerebrospinal fluid is unfeasible. For this reason, researchers have instead employed pain threshold as a proxy measure for endorphin release (Dunbar, Baron et al., 2012; Johnson & Dunbar, 2016), utilizing the opioid analgesic effect (Akil et al., 1984; Petrovic et al., 2002; Zubieta et al., 2001; for alternative measurements see Inagaki, Irwin, & Eisenberger, 2015; Nummenmaa et al., 2015). Several studies investigating synchronous behaviour have found increased pain threshold following a group rowing exercise (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Sullivan, Rickers, & Gammage, 2014); synchronized singing (Weinstein et al., 2015); drumming (Dunbar, Kaskatis et al., 2012Dunbar, Kaskatis, MacDonald, & Barra, 2012); and dancing (Tarr et al., 2016Tarr, Launay, & Dunbar, 2016). However, the relationship between pain threshold, social reward, and cooperation has rarely been examined, despite a substantial number of studies using these variables as dependent measures.

A third mechanism pertains to a more social-cognitive account, according to which synchrony is not simply the matching of behaviours but an outcome of joint action with social motivations (Keller, Novembre, & Hove, 2014; Lumsden, Miles, Richardson, Smith, & Macrae, 2012; Obhi & Sebanz, 2011). Reddish et al. (2013) suggested that the effects of synchrony are driven by the perception of successful cooperation, which improves confidence and trust, and then transfers to future cooperative tasks. Path analysis empirically supported this model (Reddish et al., 2013), and further evidence (Kurzban, 2001; Launay et al., 2013) suggests that the perceived success of a synchrony task is a critical predictor of cooperative behaviour in economic games – more so than the precise matching of movements.

Notwithstanding the ample empirical data linking synchrony with greater prosociality, as of yet, no study has systematically compared these mechanisms. Furthermore, previous research has focused on different aspects of prosociality such as liking, entitativity, and cooperation, or has conflated these aspects under terms like rapport (Cohen et al., 2013; Lakens & Stel, 2011; Tarr et al., 2015) or social bonding (Tarr et al., 2014; Wolf et al., 2016). To introduce an initial clarification, we identify two basic effects of synchrony that are representative of prosociality, one attitudinal and one behavioural (Tarr et al., 2014). Specifically, we break down prosociality into positive feelings about the other expressed in increased likeability, and trust-based behavioural cooperation as measured by an economic game. While liking and cooperation can fuel each other, liking is not a pre-requisite for economic exchange, and these two effects can be separated (Manson, Bryant, Gervais, & Kline, 2013; Tarr et al., 2016). Thus, our aim was to investigate the mechanisms that underlie the effects of synchronous movement on interpersonal liking and economic cooperation.

To this end, we manipulated synchrony and measured each of the three mediating variables via change in pain threshold measurements, self-other overlap, and perceived cooperation. We used a Trust Game to assess economic cooperation, and we also measured interpersonal liking towards the synchronizing partner. Furthermore, we employed a novel synchrony manipulation that involved individual participants interacting with another person (a pre-recorded confederate) through a video transmission with a high degree of synchrony (high-sync condition) or a low degree of synchrony (low-sync condition), and a control condition where participants did not view the video transmission. In line with previous studies, we predicted that high synchrony would lead to greater levels of cooperation and interpersonal liking in comparison to the low-synch and control conditions. Furthermore, we tested three possible pathways for these purported effects: a) a self-other overlap model, b) an endogenous opioid model, and c) a reinforcement of cooperation model. Below we assess the relative contribution of each mechanism to cooperative behaviour as measured by the Trust Game and positive attitudes towards the confederate.

2. Method

2.1. Participants

We recruited 124 participants (80 females, *M* age = 22.71, *SD* = 3.43) from a student participant pool at Masaryk University, Czech Republic, in exchange for course credit and monetary earnings from the economic game. We used a between-subjects design with random assignment to one of three conditions: high-sync (*n* = 44, 31 females; *M* age = 23.31; *SD* = 4.44), low-sync (*n* = 44, 29 females; *M* age = 22.73; *SD* = 3.07), and control (*n* = 36, 20 females; *M* age = 21.97; *SD* = 2.14). Participants were debriefed after the experiment ended. The study was approved by the Ethics Committee of the Faculty of Arts, Masaryk University.

2.2. Procedure and stimuli

Upon individually entering the laboratory room, participants were informed about the procedure and then signed a consent form. The subsequent procedure comprised three 5-min-long exercises, each followed by a pain threshold measurement. Additionally, a baseline pain threshold measurement was obtained before the first exercise. After the last exercise, participants filled out a questionnaire, and finally played a Trust game (Table S1 outlines the experimental procedure).

Each exercise consisted of 75 repetitions of three symmetric arm movements. Participants in all conditions were instructed to start each movement repetition after hearing a start signal – a drum sound that occurred at irregular intervals. In the control conditions, participants performed these movements in front of a blank wall, while in the high-sync and low-sync conditions they were instructed to synchronize their movements with another participant in a live-streaming video. In reality, however, this was a pre-recorded confederate. In the high-sync condition videos, the confederate performed exercises at a steady speed with no errors. To inhibit synchronization in the low-sync condition, the confederate's movements were distorted in three ways: 1) the speed of movements in particular repetitions varied randomly among five different speeds; 2) the confederate's reaction time was set up to vary randomly between 0.1, 0.3, and 0.5 s; and 3) the confederate made 15 movement errors in each exercise (see Fig. 1A). During the recording, the confederate followed a designed guiding beat for each particular movement, which allowed us to control movement speed and delays that simulated reaction time and the placement of errors. To avoid bonding based on facial perception, the confederate's face in the video was covered with a grey rectangle (see Supplementary Video 1).

Our pain-threshold measurement was obtained by using a pressure algometer with a standardized, continuous, and automatic distribution of pain. Motor synchronization was captured by accelerometers positioned on participants' wrists, and successful synchrony was operationalized as the minimal time-difference between participants' and the confederate's maximum acceleration points (see Supplementary Methods for details on data collection and signal processing). Furthermore, we administered a questionnaire measuring five constructs: perceived synchrony; attention to the confederate; self-other overlap; perceived cooperation; and liking of the confederate (see Supplementary Methods for details on specific scale items, their factor loadings, and scale reliability). After completing the questionnaire, each participant played a version of the Trust Game (Berg et al., 1995Berg, Dickhaut, & McCabe, 1995). Subjects in conditions with a video projection were told that they were playing the game with their interaction partner, while participants in the control condition were told that they were playing with another (anonymous) participant waiting in another room. All participants acted as player A (the trustor). Players started with 100 Czech crowns (CZK) (approximately 4 USD, enough to buy a meal locally), allocated in ten 10-CZK-coins, and chose