Evolution and Human Behavior 37 (2016) 343–349

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.ehbonline.org

Original Article

Silent disco: dancing in synchrony leads to elevated pain thresholds and social closeness

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ARTICLE INFO

Article history:
Initial receipt 28 September 2015
Final revision received 19 February 2016

Keywords:
Dance
Social bonding
Synchrony
Endorphins
Weak-link coordination game

ABSTRACT

Moving in synchrony leads to cooperative behavior and feelings of social closeness, and dance (involving synchronization to others and music) may cause social bonding, possibly as a consequence of released endorphins. This study uses an experimental paradigm to determine which aspects of synchrony in dance are associated with changes in pain threshold (a proxy for endorphin release) and social bonding between strangers. Those who danced in synchrony experienced elevated pain thresholds, whereas those in the partial and asynchrony conditions experienced no analgesic effects. Similarly, those in the synchrony condition reported being more socially bonded, although they did not perform more cooperatively in an economic game. This experiment suggests that dance encourages social bonding among co-actors by stimulating the production of endorphins, but may not make people more altruistic. We conclude that dance may have been an important human behavior evolved to encourage social closeness between strangers.

1. Introduction

Around the world people sing, make music and dance—activities which are often conducted in a group setting, accompanied by strong emotions, and can be broadly defined as "musicking" (Small, 1998). The evolutionary origin of dance, which involves synchrony of movement to others and to music, remains unclear. One prominent theory is that this behavior might have played an important role in increasing interpersonal cooperation and feelings of social closeness, thereby helping to establish and maintain group cohesion (Freeman, 2000; Kirschner & Tomasello, 2010; Reddish, Fischer, & Bulbulia, 2013; Tarr, Launay, & Dunbar, 2014).

Like most anthropoid primates, humans live in bonded social groups (Dunbar & Shultz, 2010). Bonded social groups allow their members to mount a coordinated (passive and active) defense against predators or conspecific raiders (Lehmann, Lee, & Dunbar, 2014), and provide direct fitness benefits by buffering individuals against the stresses of social life (Wittig et al., 2008) and enhancing infant survival (monkeys: Silk, Alberts, & Altmann, 2003; Silk, 2007; humans: Spence, 1954; Oesch & Dunbar, 2015). Allogrooming is a conventional mechanism for social bonding in primates, including humans, but is very expensive in terms of time, and therefore imposes a limit on the size of networks or groups that can be effectively bonded (Dunbar, Korstjens, & Lehmann, 2009). It would have been advantageous for humans to develop additional behaviors that allow bonding between multiple individuals simultaneously so as to allow us to increase the size of our social networks and communities (Dunbar, 2012a). Musicking may facilitate efficient large-scale bonding: when moving together to music, individuals can establish social closeness with the whole of the group involved (Dunbar, 2012b; Kirschner & Tomasello, 2010; Wiltermuth & Heath, 2009). To date, empirical evidence that dance can lead to social bonding has focused on the role of our innate capacity to perceive and synchronize to a rhythmic pattern (Patel, Iversen, Chen, & Repp, 2005), particularly beats embedded in music (Demos, Chaffin, Begosh, Daniels, & Marsh, 2012) or those produced by another human (Kirschner & Tomasello, 2009).

Synchronization is a pervasive behavior in many animals, playing a part in female identification of conspecific males (e.g., fireflies: Moiseff & Copeland, 2010), pair formation displays (e.g., western grebes: Nuechterlein & Storer, 1982), and courtship (e.g., fiddler crabs: Backwell, Jennions, & Passmore, 1998). The capacity to synchronize specifically to a musical beat is not uniquely human, and we share this aspect of music cognition with certain other species (Patel, Iversen, Bregman, & Schulz, 2009; Patel et al., 2008). Although there is some evidence that chimpanzees are capable of learning to spontaneously synchronize to an auditory beat (Hattori, Tomonaga, & Matsuzawa, 2013), our proclivity to produce organized rhythmic sound (music) and our mutual entrainment as occurs when we dance, remains characteristically human (Fitch, 2012).

Like mimicry (e.g., Chartrand & Lakin, 2013), synchrony has received much attention in accounts of human social-cognitive functioning (Macrae, Duffy, Miles, & Lawrence, 2008). When people perform the

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http://dx.doi.org/10.1016/j.evolhumbehav.2016.02.004
1090-5138/

same movements at the same time (i.e., synchronize), there is a co-activation of action and perception networks which is believed to blur a sense of 'other' and 'self' (Overy & Molnar-Szakacs, 2009), leading to a social bond between co-performers (e.g., Decety & Sommerville, 2003). This mechanism is argued to explain why small movement synchrony (e.g., finger tapping) increases participants' feelings of affiliation towards a tapping partner, as measured by self-reported similarity in personality (Valdesolo & Desteno, 2011) and how much participants like their co-actor (Hove & Risen, 2009; Valdesolo & Desteno, 2011). This effect is evident with real and virtual partners (Launay, Dean, & Bailes, 2014), and also manifests in prosocial behaviors such as willingness to help a partner with whom someone has synchronized (Kirschner & Tomasello, 2010; Kokal, Engel, Kirschner, & Keysers, 2011; Valdesolo & Desteno, 2011), and positive behavior in economic games (Launay, Dean, & Bailes, 2013; Wiltermuth & Heath, 2009).

Synchronization has been shown to facilitate entitativity – the feeling of being 'on the same team' (e.g., Lakens, 2010) – which can then lead to enhanced cooperation and prosociality, possibly due to a sense of collective fate (Wiltermuth & Heath, 2009). Synchronized action has also been described as increasing action understanding of others via "motor resonance" (Macrae et al., 2008), whereby self-other attentional coupling facilitates social cognition (Blakemore & Decety, 2001) by facilitating observational learning (Wilson & Knoblich, 2005) and enhancing person-related processing (Knoblich & Sebanz, 2006). This seemingly primes co-actors to establish trust and so coordinate better, as demonstrated by the fact that synchronized movement can predict success in a later joint activity that demands collaboration (Valdesolo, Ouyang, & DeSteno, 2010). Furthermore, people preferentially direct compassion and altruism toward similar others (e.g., Strürmer, Snyder, Kropp, & Siem, 2006), and synchrony (which enhances perception of similarity between co-actors) may be a means of creating a unified in-group. As a result of these various socio-cognitive effects, it is hypothesized that the prosocial effects encouraged during synchrony would be evolutionarily advantageous in other domains which require smooth coordination such as hunting, gathering, building shelters together and mutual defence against predators or conspecific raiders.

Although action–perception matching is often cited as the main mechanism underpinning the social bonding effects of synchronization, it has also been suggested that social activities such as musicking may trigger the Endogenous Opioid System (EOS; Dunbar, Kaskatis, MacDonald, & Barra, 2012; Tarr et al., 2014), which is known to be involved in social bonding in non-human primates (e.g., Ragen, Maninger, Mendoza, Jarcho, & Bales, 2013). The EOS consists of opioid-producing nuclei in the hypothalamus and opioid receptors that are distributed throughout the central nervous system and is generally studied in humans for its analgesic and reward-inducing effects (Bodnar, 2008). The Brain Opioid Theory of Social Attachment (BOTSA) highlights the fact that social attachment involves elevated levels of opioids in the brain (Machin & Dunbar, 2011; Nummenmaa et al., 2015), and that the positive effects of social interaction are similar to those induced by opiates (Machin & Dunbar, 2011). Activation of the EOS is associated with feelings of euphoria (Bodnar, 2008), interpersonal warmth, well-being, and bliss (Depue & Morrone-Strupinsky, 2005), reward (Olmstead & Franklin, 1997), social motivation (Chelnokova et al., 2014), and pleasure and pain perception (Leknes & Tracey, 2008). Given the role of the EOS in social bonding in mammals generally (Broad, Curley, & Keverne, 2006), it is argued that human behaviors which activate the EOS lead to perception of closer social bonds between co-actors (e.g., Dunbar, 2004, 2012b). According to BOTSA, the EOS may have been 'co-opted' from its more general role in pain relief and positivity to reinforce social behaviors (Eisenberger, 2015; Macdonald & Leary, 2005; Panksepp, 1999).

Group activities which increase pain threshold (a recognized proxy measure of endorphin levels; Mueller et al., 2010) include laughter (Dezecache & Dunbar, 2012; Dunbar, Baron, et al., 2012), group exercise (Sullivan, Rickers, Gagnon, Gammage, & Peters, 2011) and synchronized sport (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Sullivan & Rickers, 2013; Sullivan, Rickers, & Gammage, 2014). Rowing in synchrony elevates pain threshold compared to rowing alone (Cohen et al., 2010) or when unsynchronized (Sullivan et al., 2014), irrespective of whether the rowers are strangers or acquaintances (Sullivan & Rickers, 2013). Furthermore, active participation in group music-based activities is similarly associated with increased pain threshold (Dunbar, Kaskatis, et al., 2012). Although these studies did not measure social closeness directly, they postulate that EOS activation (specifically elevated endorphin levels) as indexed by pain threshold may play a role in the bonding that is associated with these various social activities.

The current experiment investigates changes in social bonding and pain thresholds associated with synchronized dance in groups of strangers. Existing research on the link between synchrony and social bonding has predominantly focused on synchronization of small movements such as rocking in a chair (Demos et al., 2012), walking in step (Wiltermuth & Heath, 2009), finger tapping (Launay et al., 2013), or the performance of simple arm and leg movements in time with others or a metronome (Reddish et al., 2013). These studies demonstrate that synchronization of simple movements by pairs of people or small groups leads to increased social bonding, as measured by both self-report and behavioral measures. Nevertheless, dance is arguably more than scaled up finger tapping. Few studies have investigated the effect in groups larger than two with music, or with movement conditions representative of dance (e.g., instead using conditions of walking, singing, waving cups: Kirschner & Tomasello, 2010; Wiltermuth & Heath, 2009).

In the present study, groups of four individuals performed dance movements to popular music. We used a 'silent disco' paradigm in which participants dancing in a group heard music through individual headphones; thus, any social bonding that occurs can be attributed to behavioral synchrony of dance actions. The silent disco technology allowed us to compare the synchronous condition to two non-synchronous conditions: partial synchrony (counterbalanced movements, same music) and asynchrony (unique movements and different music). Previous studies report a group synchrony effect in comparison to no-movement conditions (e.g., Wiltermuth & Heath, 2009) or sequential (cannon) movements (e.g., Reddish, Bulbulia, & Fischer, 2014; Reddish et al., 2013) and it is unclear whether the positive effects associated with synchrony are due to synchronization itself, or negative effects that arise in certain non-synchronous conditions. In addition to self-report questions and a behavioral measure of social closeness (the weak-link coordination game adapted from Wiltermuth and Heath (2009)), the present study includes pain threshold as a proxy measure of EOS activation.

2. Materials and methods

2.1. Participants

After exclusions, a final sample of 94 participants (74 females; $\bar{x}$ age = 24.29, SD = 5.29 years) was recruited in Oxford. To avoid biases in pain threshold measurements, the sample excluded pregnant, lactating or diabetic individuals (McKinney, Tims, Kumar, & Kumar, 1997), and participants who had smoked or drunk alcohol within the two hours prior to the experiment.

2.2. General study design

Test groups consisting of four strangers were randomly assigned to a movement condition (synchrony, partial synchrony or asynchrony; see Section 2.3 for details). An accelerometer Actiwatch was attached to each participant's right wrist to provide an 'activity count' per unit of time, which was interpreted as a measure of the intensity of movement (Cambridge Neurotechnology, 2008). Participants' pain thresholds were measured at the start of the experiment and immediately after the silent