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FlashReport

Moving memories: Behavioral synchrony and memory for self and others

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ABSTRACT

Establishing and maintaining connections with others is central to a fulfilling social life. In this respect, behavioral coordination provides one avenue by which interpersonal linkages can be formed. Drawing from the dynamical systems approach, the present research explored whether temporary interpersonal connections founded on coordinated behavior influence memory for self and others. To do so, we measured participants' incidental recall of self and other-relevant information after a period of either in-phase or anti-phase interpersonal coordination. While participants in the less stable anti-phase condition demonstrated the typical memory advantage for self-related compared to other-related information, this effect was eliminated when participant and confederate movements displayed in-phase coordination. These results are discussed with respect to the interplay between the systems that support interpersonal synchrony and basic social-cognitive processing.

Introduction

From bonds forged through childhood friendships to the sparks of successful first dates, connecting with others is a cornerstone of human sociality. While such interpersonal linkages can be established via a variety of routes, one intriguing pathway centers on the physical movements that occur during social interaction. Put simply, the degree to which people's movements are similar can impact how they feel about each other. Corroborating this observation, an extensive literature has demonstrated that by coordinating one's actions with others through either *imitation* (e.g., Chartrand & Bargh, 1999; Lakin & Chartrand, 2003; van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009) or *synchronization* (e.g., Bernieri, 1988; Hove & Risen, 2009; LaFrance, 1979; Wiltermuth & Heath, 2009), positive social outcomes (e.g., liking, rapport, cooperation) can be achieved.

Alongside empirical demonstrations of the association between behavioral coordination and enhanced social connections (Semin, 2007; Semin & Cacioppo, 2008), research from the dynamical systems approach has revealed that interpersonal synchrony is characterized by two specific modes of coordination: *in-phase* and *anti-phase* (Haken, Kelso, & Bunz, 1985; Schmidt, Carello, & Turvey, 1990). To illustrate, consider two children on swings. In-phase coordination would be evident if the swings were in perfect unison, such that both swings were maximally forward (or backward) at the same time. Alternatively, anti-phase coordination would display the opposite pattern, such that when one swing was maximally forward, the other would be maximally backward. Although the relationship between the positions of the swings could notionally take on any pattern, over time it would typically settle into one of these two attractor states (i.e., in-phase or anti-phase). As such, only in-phase and anti-phase movements characterize stable interpersonal synchrony (Schmidt & Richardson, 2008; Schmidt et al., 1990).

At a general level, in-phase and anti-phase coordination may serve distinct social functions. For instance, a rowing crew must coordinate in an in-phase manner by performing their strokes in unison, while a successful conversation depends on turn taking between speakers—that is, anti-phase coordination (Wilson & Wilson, 2005). Of relevance to the current investigation, recent research suggests that a specific property of coordination, namely its stability,[1] may influence fundamental aspects of social exchange. For example, stable coordination has been associated with enhanced rapport (Miles, Nind, & Macrae, 2009) and liking for interaction partners (Hove & Risen, 2009). In addition, Macrae, Duffy, Miles, and Lawrence (2008) demonstrated that memory for an interaction partner's appearance and utterances were enhanced following in-phase, compared to anti-phase coordination.[2] Thus, it appears that beyond the broad relationship between behavioral coordination and positive social outcomes, the nature of the coordination itself (e.g., mode or stability) has significant bearing on core elements of social cognition. In particular, changes in the accuracy with which information about

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[1] Stability refers to the robustness of the coordination mode to disruption or perturbation.

[2] Importantly, although in-phase and anti-phase are both stable modes of coordination, in-phase represents the global attractor state and therefore is relatively more stable than anti-phase (Haken et al., 1985; Kelso, 1995).

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others is recalled (Macrae et al., 2008) points to a relationship between coordination mode and social interaction that is grounded in basic cognitive processes. This observation raises a number of interesting questions. Notably, if person perception is modulated by coordination mode, are other core social-cognitive phenomena influenced in a similar manner? To this end, we considered whether the processing of self-relevant information is impacted by the nature of interpersonal coordination.

The self-reference effect (SRE) in memory refers to the preferential encoding and memory for information related to the self compared to other people (Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997). Self-memory advantages have been demonstrated across a variety of task contexts and are associated with distinct patterns of neural activity (Macrae, Moran, Heatheron, Banfield, & Kelley, 2004; Powell, Macrae, Cloutier, Metcalfe, & Mitchell, in press). Importantly, however, when there is an existing social connection between self and others the magnitude of the self-memory advantage is typically attenuated (Symons & Johnson, 1997). For example, information about a close friend tends to be processed in an equivalent manner to self-relevant information. Pertinent to the present investigation, the self-memory effect provides a context in which the effects of coordination stability on social-cognitive functioning can be further illuminated. In particular, we suspect that social connections founded on interpersonal synchrony (Hove & Risen, 2009; Macrae et al., 2008; Marsh, Richardson, & Schmidt, 2009; Miles et al., 2009; Schmidt & Richardson, 2008), although temporary, may also impact memory performance. Specifically, the magnitude of self-memory effects may be modulated by the relative stability of interpersonal coordination (i.e., anti-phase > in-phase).

Method

Participants and design

Thirty-six female undergraduates participated in exchange for course credit. The experiment had a single-factor (coordination mode: in-phase or anti-phase) between-participants design.

Materials

Four target lists, each comprising 35 country names, were constructed and balanced for number of syllables, geographic location (i.e., continent) and familiarity as rated by four independent judges. These lists were read aloud and digitally recorded using Audacity software (version 1.3). The use of these lists was counterbalanced between participants.

Procedure

Participants arrived at the laboratory where a female confederate, feigning to be a second participant, was already present. The experimenter explained that the investigation was a dual-task study in which they would be required to repeat out loud words they heard over head-phones and perform repetitive arm curls (i.e., arm extension/flexion) while holding a wooden rod (5 cm diameter, 60 cm long). The participant and confederate were seated in chairs arranged in a perpendicular manner such that they were in full view of one another (see Fig. 1). Their movements were tracked using a magnetic motion tracking system (Polhemus Liberty 8, Polhemus Corporation, Colchester, VT) and recorded at 120 Hz using custom written software. Words (i.e., countries) were presented over head-phones once every 3 s, and alternated between the participant and the confederate (i.e., each individual heard a word every 6 s). In addition to the word list, participants

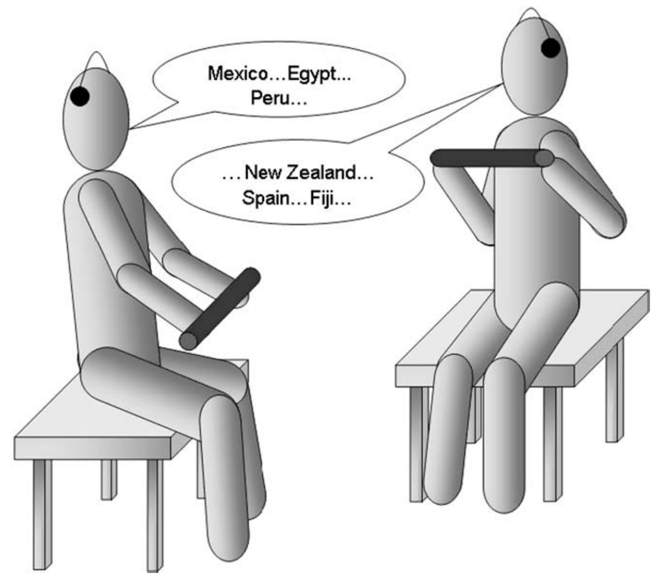

Fig. 1. Diagram of the experimental set-up showing anti-phase coordination.

also heard a metronome tone (1.5 Hz) and were instructed to perform the arms curls in time with this. The confederate did not hear a metronome tone but instead intentionally coordinated with the participant in either an in-phase (i.e., the confederate was at full extension when participant was at full extension) or an anti-phase (i.e., the confederate was at full extension when participant was at full flexion, see Fig. 1) mode (Macrae et al., 2008). Participants were instructed that if they did not hear the country name clearly enough to be able to repeat it, or did not recognize it they were to say "don't know".

Upon completion of this stage of the experiment, participants performed a surprise memory test. The test was composed of 140 items: 35 countries spoken by the participant, 35 countries spoken by the confederate and 70 unspoken countries that acted as fillers. Items were presented on a computer screen individually and in a unique random order for each participant. Participants responded to each item by identifying it either as a word which they had spoken (i.e., 'old-self' word), a word that their partner had spoken (i.e., 'old-other' word), or a word that had not been spoken in the earlier stage (i.e., 'new' item). After they had completed the memory test participants were funnel debriefed with respect to any suspicions they had about the confederate's role. All participants reported that they thought the confederate was in fact another participant. They were then debriefed and dismissed.

Results

Movement

The relative phase relationship between participant and confederate movements was calculated as a manipulation check (i.e., to ensure the confederate had successfully coordinated in the intended mode) and to enable a comparison of the stability of coordination between the in-phase and anti-phase conditions. Prior to analysis, each time series of movement data was centered around 0 and low-pass filtered using a 10 Hz Butterworth filter. Mean relative phase was calculated separately for each participant and normalized to a range of 0–180°. In-phase coordination is indicated by a mean relative phase angle approximating 0° and anti-phase coordination is indicated by a mean relative phase angle approximating 180°.

As expected, the mean relative phase angle for each condition approximated the intended coordination mode (in-phase: $M = 4.7°$; anti-phase $M = 169.1°$). Deviation from intended phase was calculated for each participant by subtracting their mean relative phase angle from the intended phase angle (0° for in-phase; 180° for anti-phase). Absolute values were compared between conditions using an independent *t*-test [$t(34) = 2.76$, $p < .01$, $d = 0.91$]. This revealed that the relationship between participant and confederate movements were significantly closer to the intended phase angle for those in the in-phase compared to the anti-phase condition. Standard deviation of relative phase was also compared between conditions using an independent *t*-test [$t(34) = 8.10$, $p < .001$, $d = 3.29$] which indicated greater variability (i.e., less stability) for pairs in the anti-phase condition ($M = 25.8$) than the in-phase condition ($M = 16.1$). Together these results indicate that coordination was less stable in the anti-phase compared to the in-phase condition.

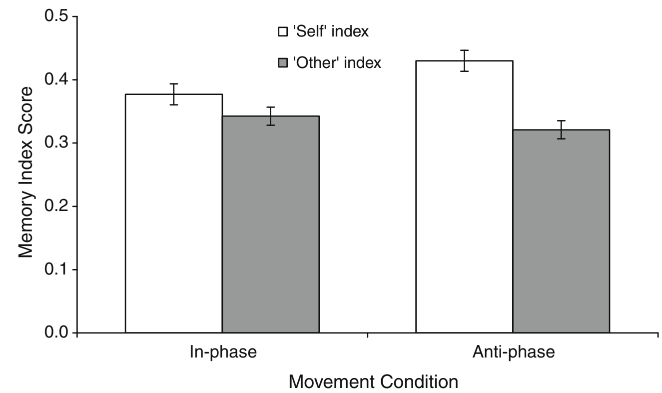

Fig. 2. Memory index score (proportion of items correctly identified as old also correctly identified as self – 'self index', or other – 'other index') as function of movement condition.

General memory performance

Prior to analysis, items the participant had failed to recognize during the encoding stage (1.3% of trials) were omitted. Two indices of general memory performance commonly used in research of this nature (e.g., Cycowicz, Friedman, Snodgrass, & Duff, 2001; Raye & Johnson, 1980) were calculated for each participant and compared between conditions. First, participants' ability to discriminate old from new items was calculated as the sum of hits (defined as identifying any old item as 'old-self' or 'old-other') and correct rejections (defined as identifying a new item as 'new') as a proportion of the total number of test items. No difference in old–new discrimination was found between conditions [$t(34) = 1.22$, $p = .23$]. Second, recognition errors were calculated as the sum of misses (defined as identifying an old item as 'new') and false positives (defined as identifying a new word as 'old-self' or 'old-other') as a proportion of the total number of test items. Again this did not differ between conditions [$t(34) = 0.04$, $p = .96$]. Together these results indicate that general memory performance did not differ as a function of movement condition. Any differences with respect to the emergence of self vs. other memory effects therefore need not be qualified by considering differences in participants' ability to discriminate old from new items, nor in terms of the errors made.

Self vs. other memory performance

To examine the nature of participants' memory for self vs. other words, separate indices of memory performance were calculated for words the participant said (i.e., self index) and for words the confederate said (i.e., other index). Each index was defined as the proportion of words correctly identified as old that were also correctly identified as 'old-self' (self index) or 'old-other' (other index). These indices were then compared using a 2 (Condition: in-phase or anti-phase) × 2 (Index: self or other) mixed model analysis of variance with repeated measures on the second factor.[3] This revealed a main effect of Index [$F(1, 34) = 31.52$, $p < .001$, $\eta_p^2 = .48$] which was qualified by a Condition × Index interaction [$F(1, 34) = 8.62$, $p < .01$, $\eta_p^2 = .20$, see Fig. 2]. Post-hoc tests (Tukey *a*, $p < .05$) revealed that participants in the anti-phase condition correctly recalled a significantly greater proportion of the words they had uttered than words the confederate had said ($M_{self} = .43$, $M_{other} = .32$). Importantly, no such effect emerged for participants in the in-phase condition ($M_{self} = .38$, $M_{other} = .34$). Further, there were no differences between conditions on either the self or other memory indices.

Movement and self vs. other memory

To further explore the relationship between coordination stability and self vs. other memory, each participant's score on the 'other index' was subtracted from that on the 'self index' to create a memory difference score. Positive values represented a relative memory advantage for 'self' over 'other' words, and negative values an advantage for 'other' over 'self' words. The relationship between the standard deviation of relative phase (i.e., coordination stability) and memory difference score was considered across the entire sample. This revealed a significant positive relationship [$r(36) = .39$, $p < .05$, see Fig. 3], thereby further highlighting the notion that more stable coordination was accompanied by a larger attenuation of the self-memory advantage.

Discussion

In the current inquiry, we explored whether interpersonal connections founded on coordinated behavior influence social cognition in a manner resembling the effects characteristic of more

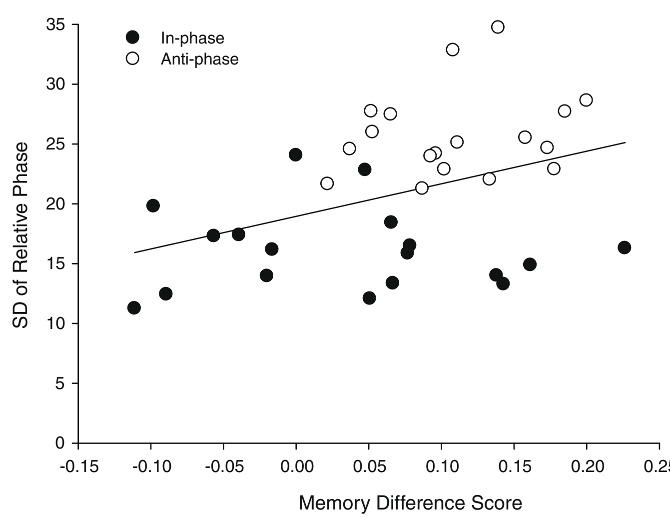

Fig. 3. Scatter plot of memory difference score (positive values = 'self' > 'other'; negative values = 'other' > 'self') vs. standard deviation of relative phase (higher values represent less stable coordination).

[3] The same analysis performed on raw memory scores (% correct) yielded an identical pattern of results.

long-standing relationships. To do so, we measured participants' incidental recall of self- and other-relevant information after a period of either in-phase or anti-phase interpersonal coordination. The results revealed that while anti-phase coordination yielded a typical self-memory advantage (i.e., self > other), this effect was eliminated when movements were coordinated in-phase. Importantly, this effect is consistent with the attenuation of the self-memory advantage seen for established interpersonal relationships (Symons & Johnson, 1997). Moreover, coordination stability was shown to influence the magnitude of the self-memory advantage, such that less stable coordination was associated with a greater difference between memory for self and an interaction partner.

It has been suggested that stable interpersonal synchrony creates a 'mooring effect' (Marsh et al., 2009) or an 'attentional union' (Macrae et al., 2008) thereby enhancing the experience of connectedness between interacting individuals (Schmidt & Richardson, 2008). While the present results are consistent with these claims, the underlying mechanisms that drive performance remain unclear. To this end, in-phase (compared to anti-phase) coordination has been shown to be less cognitively demanding (e.g., Shockley & Turvey, 2005, 2006; Temprado & Laurent, 2004). However, we found no evidence of an influence of coordination mode on overall memory performance. Instead the effects of condition were limited to *relative* differences in the recall of self-relevant compared to other-relevant information, suggesting that differences in cognitive load do not account for the current findings. Alternatively, research exploring behavioral imitation suggests that being mimicked moderates the manner in which information is processed. Specifically, imitation leads to more interdependent, or 'other-focused' information processing (van Baaren, Horgan, Chartrand, & Dijkmans, 2004), heightening perceptions of closeness and facilitating social connections (Ashton-James, van Baaren, Chartrand, Decety, & Karremans, 2007). In the current context, a relative shift in attentional focus from self to other that is triggered by stable in-phase synchrony may explain the attenuation of the self-memory advantage (van Baaren, Maddux, Chartrand, de Bouter, & van Knippenberg, 2003). This hypothesis, however, awaits further investigation.

To summarize, the present research highlights the interplay between the nature of behavioral coordination and the modulation of basic social-cognitive processes. In short, social connections founded on stable interpersonal synchrony appear to shape memory function in a manner similar to that of more long-standing relationships.

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