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IT'S ALL IN THE TIMING: INTERPERSONAL SYNCHRONY INCREASES AFFILIATION

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The tendency to mimic and synchronize with others is well established. Although mimicry has been shown to lead to affiliation between co-actors, the effect of interpersonal synchrony on affiliation remains an open question. The authors investigated the relationship by having participants match finger movements with a visual moving metronome. In Experiment 1, affiliation ratings were examined based on the extent to which participants tapped in synchrony with the experimenter. In Experiment 2, synchrony was manipulated. Affiliation ratings were compared for an experimenter who either (a) tapped to a metronome that was synchronous to the participant's metronome, (b) tapped to a metronome that was asynchronous, or (c) did not tap. As hypothesized, in both studies, the degree of synchrony predicted subsequent affiliation ratings. Experiment 3 found that the affiliative effects were unique to *interpersonal* synchrony.

Interpersonal coordination is typically divided between behavioral matching (e.g., mimicry) and interactional synchrony (e.g., movement matched in time; Bernieri & Rosenthal, 1991). A good deal of research has been conducted to understand the mechanisms, moderators, and effects of mimicry. Less attention has been devoted to synchrony. Although widespread anecdotal evidence suggests that moving synchronously with others is associated with affiliation (e.g., Macdonald & Wilson, 2005) and it has been argued that interpersonal coordination may have been selected evolutionarily for its role in social cohesion (Freeman, 2000; McNeill, 1995), the causal effect of interpersonal synchrony on affiliation has not been experimentally established. The current research addresses this issue.

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BEHAVIORAL MATCHING

Behavioral matching, the well-documented tendency to mimic an interaction partner in body posture, laugh, speech accent, and syntax (for a review see Lakin, Jefferis, Cheng, & Chartrand, 2003), has been demonstrated to develop early and occur automatically. In addition, research suggests that mimicry promotes affiliation. For example, when a confederate mimicked participants' posture and movements, they liked the confederate more (Chartrand & Bargh, 1999). Behavior matching does not require that the behaviors be matched in time. In fact, research on mimicry often includes a lag, such that mimicry is adopted several seconds after the original behavior. If the delay is too short, the participant is more likely to detect the mimicry (Bailenson, Beall, Loomis, Blascovich, & Turk, 2004), and overt detection can have negative effects on affiliation (Bailenson, Yee, Patel, & Beall, 2007).

Mimicry is thought to occur because of the tight neural link between perception and action (e.g., Iacoboni et al., 1999). According to common coding theory, perception and action plans are coded in a common representational medium (Hommel, Müsseler, Aschersleben, & Prinz, 2001), and research on mirror neuron systems supports this claim (e.g., Gallese, Keysers, & Rizzolatti, 2004). Perceiving another's movements activates one's own action system for that same movement (Knoblich & Sebanz, 2006; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996), increasing the likelihood and ease of initiating a matched action (Brass, Bekkering, & Prinz, 2001).

These perception-action linkages have also been proposed to play a role in generating affiliation and social cohesion (Chartrand & Bargh, 1999; Dijksterhuis & Bargh, 2001; Gallese, 2003; Hurley, 2008). Perceiving an agent's action automatically and directly maps onto the observer's action system, creating a neural coupling between the agent and observer (Blakemore & Decety, 2001; Semin & Cacioppo, 2008). Thus, shared representations for perception and action naturally extend to shared representations for self and other (Gallese, 2003; Hurley, 2008). This "self-other equivalence" may promote meaningful social bonds and interpersonal closeness by helping people understand others' actions (e.g., Iacoboni, 2005; Meltzoff, 2005) or by increasing people's tendency to project positive views of the self to others (Otten & Wentura, 2001; Smith, 2008). Note that self-other "overlap" in perception/action systems resonates with earlier metaphorical treatments of self/other overlap in social interactions. For example, building on work by James, Mead, and Lewin, Aron and colleagues (Aron, Aron, Tudor, & Nelson, 1991) established that close interpersonal relationships are characterized by "including the other in the self." And, more recently, Fiske (2004) proposed that one major type of social relationship is a communal sharing relationship, wherein the self and other are deeply connected.

SYNCHRONY

Synchronized behaviors are those that are matched in time. Synchrony can occur with different actions, such as the coordinated movements of an athletic team or an orchestra; or with the same actions, such as pairs walking in stride (cf. van Uelzen, Lamoth, Daffertshafer, Semin, & Beek, 2008). Unlike behavioral match-

ing, synchrony requires anticipating others' behaviors to coordinate movement timing (Keller, 2008; Sebanz, Bekkering, & Knoblich, 2006). In conversation, for example, the listener's body moves in synchrony with the speaker's rhythm of speech (Condon & Ogston, 1966; Hadar, Steiner, & Rose, 1985); and even neonates have been shown to synchronize movements with speech rhythms (Condon & Sander, 1974). The unintentional tendency for two or more people to entrain their periodic movements is often examined with dynamical systems approaches. For example, when seated next to each other, two individuals' swinging legs naturally come into phase (Schmidt, Carello, & Turvey, 1990), as do their rocking chair periodicities (Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007), and finger oscillations when instructed to attend to the others' movements (Oullier, de Guzman, Jantzen, Lagarde, & Kelso, 2008). Larger groups also synchronize their movements as exemplified by phase-locked rhythmic applause in concert halls (Neda, Ravasz, Brechet, Vicsek, & Barabasi, 2000). Despite the rich literature documenting synchrony, however, there is relatively little research examining the underlying mechanisms of interpersonal synchrony or the effects of being in sync.

Because synchrony relies on fine-grained timing, structures such as the cerebellum and basal ganglia are likely involved (Ivry & Spencer, 2004). And, recent work suggests that the tight perception-action linkages that promote mimicry may also be involved in synchrony. A recent EEG experiment on interpersonal finger tapping revealed an oscillatory component that seems to enhance mirror system activity during synchronous, but not asynchronous behavior (Tognoli, Lagarde, DeGuzman, & Kelso, 2007).

Thus, as with mimicry, synchrony may promote self-other overlap in neural representation, with corresponding effects on affiliation. In addition, because synchronous behavior is often associated with close, communal relationships (Smith, 2008), synchronous behavior may be interpreted as evidence of a close relationship, which in turn, could promote more closeness. Whether stemming from direct neural overlap for self and other, and/or more indirect interpreted cues for a shared relationship, we contend that *synchronous* behaviors will promote more affiliation than matched behaviors alone (e.g., Chartrand & Bargh, 1999; LaFrance, 1982). That is, holding behavior constant, we predict that synchrony will boost affiliation.

Past research offers supportive, but inconclusive evidence for this claim. Happily married couples, for example, showed more responsive body language than dissatisfied couples during counseling sessions (Julien, Brault, Chartrand, & Begin, 2000). Additionally, in mock student-teacher interactions, the interactants' ratings of rapport correlated with outside observers' ratings of movement synchrony (Bernieri, 1988); however, critics contend that observers' ratings might reflect the positivity, not the synchrony of interaction (Capella, 1990). Moreover, based on these correlational results, it is possible that liking leads to more synchrony (rather than synchrony leading to liking). The current experiments examined affiliation following an interaction in which the degree of synchrony was quantified (Experiments 1 to 3) and manipulated (Experiments 2 and 3).

EXPERIMENT 1

Experiment 1 tested the relationship between affiliation and objectively quantified (rather than subjectively rated) synchrony. We predicted that participants who tapped in synchrony with the experimenter would like the experimenter more.

METHOD

Participants. Forty-four Cornell University students (19 females) voluntarily participated.

Materials and Procedure. Participants tapped their right index finger on a Roland SPD-6 drum machine, keeping time with a moving target on a computer screen. The 1 cm wide target bar oscillated 2 cm vertically within a box icon. Participants tapped when the bar hit the bottom of the box, making finger and target movements compatible in amplitude and direction. The experimenter sat to the participant's right, matching her finger movements to a separate moving target.[1] A divider placed on the screen obstructed the view of the other's target so that participants and the experimenter could not see each other's target. The experimenter tapped on the drum machine's right-most pad, while the participant tapped on its left-most pad (approximately 25 cm apart). Each other's finger movements were peripherally visible and taps produced a light, audible "thud."

The tapping portion of the experiment consisted of 12 trials and lasted approximately 2.5 minutes. Half of the trials were presented at a fast tempo and half at a slow tempo to ensure that participants tracked their targets, rather than simply memorizing the tempo. Participant's targets occurred 24 times per trial with inter-onset-intervals (IOI) of 510 ms in fast trials and 570 ms in slow trials.[2]

After the tapping task, participants filled out a questionnaire about the task (difficulty, enjoyment, perceived tapping success, etc.), and about the participants' state (overall mood, mental exhaustion, and physical exhaustion). The critical measure was participants' affiliation with the experimenter. All responses were on a 9-point Likert scale. The measure of affiliation: "How likable was the experimenter?" was anchored at 1 with "extremely dislikable" and at 9 with "extremely likable." A final form probed for suspicion. Participants placed questionnaires in a large "anonymous" envelope.

The critical measure for tapping was the degree of interpersonal synchrony between the participant and experimenter. The degree of synchrony was analyzed in terms of (1) the mean unsigned asynchrony between the participant's and experimenter's taps and (2) the percentage of participant and experimenter's taps

1. The experimenter explained that she would tap to her own target and did not offer an explanation for her actions (no participant asked why or seemed troubled by it).

2. The experimenter tapped with a separate metronome randomly assigned to be either coincident or 50% faster than the participant's. During this short task, however, participants did not acquire the skill necessary to tap consistently with their target (see Results and Discussion). Because participants did not keep accurate time with their own metronome, we could not compare those that were matched with those who were mismatched with the experimenter. Instead, our analyses collapsed across the intended manipulation and examined actual tapping behavior. Experiments 2 and 3 used a longer task (and practice trials) to ensure that participants tapped with their metronome, allowing us to make comparisons across randomly assigned conditions.

that occurred "together," where together was defined as co-occurrence within a 100 ms temporal integration window. Previous research indicates that when two auditory events occur within 100 ms, they are integrated in a bound unit (Yabe et al., 1998).

RESULTS AND DISCUSSION

In this short task, participants did not acquire the skill to tap consistently with their target metronome. On average, participants' consistency between taps and targets (i.e., circular variance [*CV*] = .49; Fisher, 1993) was above the previously used threshold for visuomotor synchronization success ($CV \approx 0.42$; Repp, 2003). We examined interpersonal synchrony, however, by examining the actual tapping of participants and the experimenter.

As predicted, the degree of *interpersonal* synchrony between participants and the experimenter predicted how much participants liked the experimenter. Participants who tapped closer and more consistently with the experimenter rated her more likeable on the subsequent questionnaire. High likability ratings corresponded with small mean asynchronies between the participant and experimenter (r = -.372, p = .014) and with high percentages of taps occurring within 100 ms (r = .386, p = .012). Likability ratings did not correlate with other questionnaire measures (task enjoyment, task difficulty, and perceived tapping success for themselves and the experimenter), nor with individual tapping performance (tempo or variability of tapping, ps > .3).

These results demonstrate a positive relationship between synchrony and affiliation even when synchrony was objectively quantified. However, the correlational analysis makes the causal direction unclear. Did participants like the experimenter because they tapped in synchrony with her or did they tap in synchrony because they liked her? Experiment 2 was designed to test the causal direction of the relationship.

EXPERIMENT 2

To determine whether being "in sync" creates a feeling of affiliation, Experiment 2 manipulated the experience of synchrony and included a base-line measure of likeability. To successfully manipulate the experience of synchrony, participants engaged in a long tapping task so that they would achieve the skill necessary to keep accurate time with their target.

METHOD

Participants. Seventy-four Cornell University students (54 females) participated for course credit. They were randomly assigned to one of three between-subjects conditions: tapping in synchrony with the experimenter (n = 26), tapping out of synchrony with the experimenter (n = 24), or tapping alone (n = 24). Five were excluded from analysis due to suspicions about the hypothesis (3 from the synchronous condition, and 2 from the asynchronous condition).

Materials and Procedure. As in Experiment 1, participants tapped their right index finger keeping time with a moving target, while seated next to the experimenter. The tapping portion of the experiment consisted of 4 practice trials and 32 test trials. Half of the trials were presented at a fast tempo and half at a slow tempo. In all three conditions, the participant's targets occurred 24 times per trial with IOIs of 520 ms in fast trials and 600 ms in slow trials. In the synchrony condition, the experimenter tapped with a separate moving target matched in tempo to the participant's rates of 520 and 600 ms IOIs. In the asynchrony condition, the experimenter tapped with targets that were 33% faster than the participant's, or 390 and 450 ms IOIs. In the alone condition, the experimenter rested her hands in her lap. The tapping task lasted approximately 10 minutes.

Prior to tapping, a preliminary questionnaire checked for baseline differences in affiliation with the experimenter. Participants were told that "numerous experimenters were running the study and in order to check for differences," they should rate the clarity of the instructions and the experimenter's friendliness (a proxy for likability). In actuality, one experimenter, who was blind to the hypothesis, ran all participants. After the tapping task, participants filled out a questionnaire about the task (difficulty, enjoyment, perceived tapping success, etc.), and about the participants' state (overall mood, mental exhaustion, and physical exhaustion). As in Experiment 1, the critical measure was participants' affiliation with the experimenter. A final form probed for suspicion. Again, the critical measure for tapping was the degree of interpersonal synchrony between the participant and experimenter.

RESULTS AND DISCUSSION

Affiliation and Measured Synchrony. Replicating Experiment 1, the degree of *interpersonal* synchrony between the participant and experimenter predicted how much participants liked the experimenter. Participants who tapped closer in time and more consistently with the experimenter liked her more. Across conditions, high likability ratings correlated with small mean asynchronies between the participant and experimenter (r = -.418, p = .005), and with high percentages of taps occurring within the 100 ms integration window (r = .401, p = .007). When we control for base-line ratings, the partial correlations remain significant (ps = .001). There was no relationship between participant's individual tapping performance (tempo or variability of tapping) and likability ratings (ps > .3).

Affiliation and Manipulated Synchrony. Measures of individual tapping indicated that participants successfully matched their target metronome in this long task. Participants' consistency between taps and targets (CV = .36) was below the threshold for visuomotor synchronization success and did not differ between conditions (p > .6). Participants' tapping tempo (Mean ITI) was accurate in all conditions for fast (M = 520.7) and slow trials (M = 595.6); and did not differ between conditions (ps > .9). Results for experimenter tapping tempo indicate that she also successfully tapped at the target frequency in all conditions. Thus the manipulation was successful; participant and experimenter taps were more coordinated in the synchrony condition than the asynchrony condition (in terms of mean asynchronies and percent of taps co-occurring within 100 ms, ps < .001).

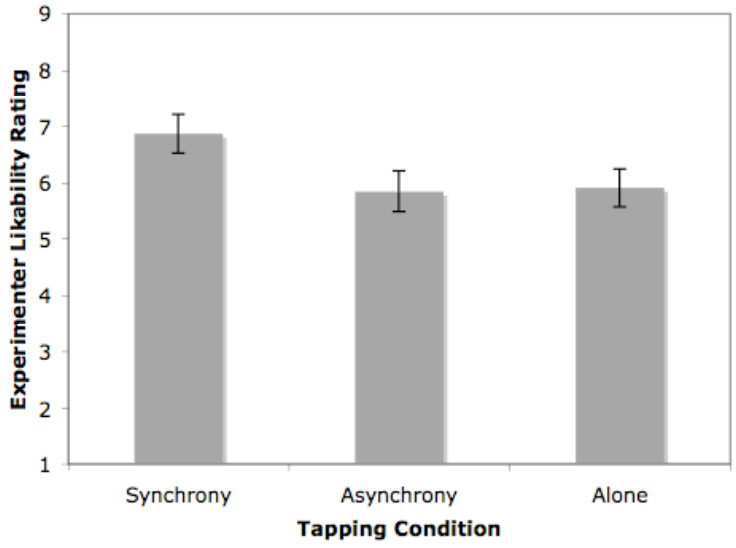

FIGURE 1. Mean likability ratings by tapping condition. Error bars represent standard error.

The critical test showed that participants in the synchrony condition liked the experimenter significantly more (M = 6.87) than those in the asynchrony condition liked her (M = 5.91), $t(43) = 2.48$, $p = .017$, $d = 0.74$ (see Figure 1). There were no differences between groups in the preliminary questionnaire on friendliness, $p > .4$, and the results remain significant when controlling for base-line ratings of friendliness.

Likability was not mediated by any of the other measured subjective factors. In fact, there were no significant differences between synchrony and asynchrony conditions observed in t-tests on task enjoyment, task difficulty, mood, physical exhaustion, mental exhaustion, or perceived success of their own or the experimenter's synchronization with their respective metronome ($.1 < ps \leq .9$).

The alone condition was included to test whether being "in sync" enhanced feelings of affiliation. We predicted that, compared to the alone condition, experiencing synchrony with the experimenter would increase feelings of affiliation for her. Thus, we predicted that those in the synchronous condition would like the experimenter more than those in the control condition and asynchronous condition liked her. Alternatively, being "out of sync" might diminish feelings of affiliation, resulting in lower experimenter likability ratings by participants in the asynchrony condition than the alone and synchrony conditions. For example, if participants actively inhibited the tendency to fall into sync, they may have inferred that it was not a close relationship. Finally, it was possible that those in the synchronous AND asynchronous conditions would like the experimenter more than those in the control condition because both of the experimenter tapping conditions included behavioral matching, while the control condition did not. This third possibility seemed unlikely because participants were completely aware of the behavioral matching (regardless of whether they were aware of the synchrony). In other words, because the effect of mimicry on affiliation seems to depend on it going

unnoticed, we did not expect that the behavior matching in the asynchronous condition would promote affiliation compared to the non-tapping control group.

Following a one-way ANOVA, $F(2, 66) = 2.69$, $p = .075$, we used the least significant difference test to make planned comparisons with the alone condition. We observed higher ratings of experimenter likability in the synchrony condition ($M = 6.87$) than the alone condition ($M = 5.92$), $p < .05$, and no difference between the alone and asynchronous conditions, $p > .9$ (see Figure 1). These results indicate that affiliation increases after experiencing interpersonal coordination, rather than decreasing after a lack of coordination. In addition, the results reaffirm the importance of behavioral matching going undetected if it is to increase affiliation. This study is the first of which we are aware to demonstrate a causal influence of synchrony on affiliation.

EXPERIMENT 3

Experiment 3 tested our claim that synchrony promotes feelings of affiliation because of the interpersonal nature of the coordination. It is possible that participants in the first 2 studies liked the experimenter more simply because they were experiencing synchrony (and not necessarily interpersonal synchrony).[3] Experiment 3 tested whether affiliation would arise from experiencing synchrony that was inanimate, rather than interpersonal.

METHODS

Participants. Forty-seven Cornell University students participated for course credit.

Materials and Procedure. Participants sat next to a non-tapping experimenter and tapped along with a visual moving target (36 total trials at 520 and 600 ms IOIs), while an auditory metronome (matched in loudness to the tapping) pulsed either synchronously or asynchronously with the participant's visual target, or was silent in a third between-subjects condition. Afterwards, participants completed the same set of questionnaires as they did in the previous studies. Thus, participants' experience was identical to Experiment 2, except that they tapped either in sync or out of sync with a metronome rather than with the experimenter.

RESULTS AND DISCUSSION

As in Experiment 2, measures of individual tapping indicated that participants successfully matched their target metronome ($CV = .26$). Thus, the manipulation of synchrony was successful.

3. Perhaps tapping in sync increased processing fluency, which, in turn, increased participants' general hedonic state and led them to like the experimenter more. This alternative seems unlikely because synchrony was not related to their feelings about the task (i.e., how much they liked the task or how difficult they found it) or their mood.

We found no differences between conditions for experimenter likability ratings ($p > .17$). Tapping in synchrony with a metronome did not lead participants to like the experimenter sitting beside them more ($M = 6.88$) than when the metronome was out of sync with their tapping ($M = 7.60$) or was silent ($M = 6.50$). In addition, as in the previous experiments, there was no effect of condition on task enjoyment, difficulty, or mood. Thus it appears that the degree of *interpersonal* synchrony was the critical factor contributing to likability in Experiments 1 and 2 rather than a general preference for any experience of synchrony (note, however, that this conclusion is drawn from a null result and therefore should be interpreted cautiously).

GENERAL DISCUSSION

The current experiments demonstrate that interpersonal synchrony leads to affiliation. First, the measured degree of interpersonal synchrony in Experiments 1 (3 minute tapping task) and 2 (10 minute tapping task) correlated with subsequent affiliation ratings. In addition, the causal direction was examined in Experiment 2, and we found that participants assigned to tap in synchrony with the experimenter liked her more than participants assigned to tap out of synchrony or alone. Because the participant's and experimenter's movements were matched, we can be certain that the effect was due to the timing of the movements (i.e., affiliation was produced by synchrony rather than mimicry). Together with Experiment 3, we conclude that *interpersonal* synchrony was the critical factor contributing to likability rather than a general effect of synchrony.

The matched actions during the asynchrony condition in Experiment 2 fall within the typical definition of mimicry,[4] but failed to boost affiliation ratings compared to the alone control condition. This finding reaffirms the need for mimicry to go unnoticed in order for it to increase affiliation (Bailenson, Yee, Patel, & Beall, 2007). What about synchrony? Must it go unnoticed as well? In our studies, participants were asked in the suspicion probe whether they noticed anything about how their tapping related to the experimenter's tapping. A handful of participants reported the relationship incorrectly (e.g., claiming that they were not tapping together when they were assigned to tap together or vice versa), a minority of participants correctly reported the tapping relationship, and the majority of participants did not report any specific relationship. There was no difference in affiliation ratings for those who correctly reported whether they were in sync and those who did not notice the relationship (there were not enough incorrect participants to compare them to the others). Although most participants did not report the tapping relationship, because the synchrony was rather overt, we would not claim that it went entirely unnoticed. Future work should examine whether noticing synchrony interferes with, promotes, or does not affect affiliation.

While we show that synchrony can have affiliative effects similar to previous work on mimicry, open questions remain for whether moderators of mimicry also

4. A traditional account of mimicry simply requires that actions match in form. Recently, however, Semin and Cacioppo (2008) suggested that mimicry only describes non-periodic matched movements. Thus, according to Semin and Cacioppo, there was no mimicry in the synchronous and asynchronous conditions because the actions were periodic. Regardless of one's perspective on mimicry, however, the difference between the two conditions is the presence or absence of synchrony.

apply for synchrony. For example, do people synchronize less with a disliked or stigmatized individual or synchronize more when their self-construal is interdependent rather than independent and when they have an affiliation goal?

In addition, it is unclear whether synchrony and mimicry rely on the same neural mechanisms and whether affiliation results for the same reason in each case. Mimicry research suggests that affiliation occurs because of self-other representational overlap. The affiliative effects of synchrony may rely on this same neural mechanism. During interpersonal synchrony, when self- and other-produced movements are highly aligned in both form and time, the neural activations for perceptions of self and other closely overlap, which may interfere with the ability to discriminate self- versus other-produced action (Georgieff & Jeannerod, 1998), in essence blurring the self/other distinction. Less self/other distinction potentially offers a closeness and ease of understanding that yields affiliation. Or during self-other overlap, positive views of ourselves may extend to the other (e.g., Galinsky, Martorana, & Ku, 2003). Or, within a dynamical systems framework, people could experience greater social synergy when coupled oscillators are in synchrony because energy in the dyadic system is minimized in this more stable coordination pattern (Marsh, Richardson, Baron, & Schmidt, 2006).

Alternatively, because synchronous behaviors are associated with communal relationships, it is possible that people infer closeness when they notice synchrony. For example, touch, physical proximity, shared resources, and synchronized movements act as cues to a communal sharing relationship (Fiske, 2004; Smith, 2008). Future work could look at more covert, subtle forms of synchrony in order to decouple higher-level cues for a shared relationship from lower-level self/other overlap. In addition, future work could manipulate synchrony by using a confederate to reduce the possibility that the effects require a "higher status" individual.

While the exact mechanism remains clouded, the clear effect of interpersonal synchrony on affiliation extends similar well-documented effects in mimicry by incorporating the crucial aspect of time. Freeman (2000) argues that music and dance evolved to serve as a technology of social bonding. Bandmates often report a great deal of connection. And it's no wonder that couples' synchronous movements in dancing (not to mention in sex) are an affiliative bonding activity—while you may not know if you are in your partner's heart, you know you are in their mind. In a world rife with isolation, the aligned representations in interpersonal synchrony may provide a means for togetherness and connection.

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