

Synchronization Can Influence Trust Following Virtual Interaction

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Abstract

Synchronization has recently received attention as a form of interpersonal interaction that may affect the affiliative relationships of those engaged in it. While there is evidence to suggest that synchronized movements lead to increased affiliative behavior (Hove & Risen, 2009; Valdesolo & DeSteno, 2011; Wiltermuth & Heath, 2009), the influence of other interpersonal cues has yet to be fully controlled. The current study controls for these features by using computer algorithms to replace human partners. By removing genuine interpersonal interaction, it also tests whether sounds alone can influence affiliative relationships, when it appears that another human agent has triggered those sounds. Results suggest that subjective experience of synchrony had a positive effect on a measure of trust, but task success was a similarly good predictor. An objective measure of synchrony was only related to trust in conditions where participants were instructed to move at the same time as stimuli.

Keywords: synchronization; trust; agency

Synchronization Can Influence Trust Following Virtual Interaction

Human beings are social, and in order to interpret the complex world of other people we make judgments about whom we can trust based on minimal cues. While experience of others may be the ideal way to judge their reliability, when this information is not available we can use information such as sharing similar values, friends, or having a similar appearance to ourselves in order to decide if we should class them as a potential ally. However, in our attempts to determine who might be dependable we also take into account other, less clearly defined factors, some of which may subconsciously relate to co-operative strategies.

It has been suggested that synchronized movement may relate to social behavior (e.g. Sebanz, Bekkering, & Knoblich, 2006), but research has concentrated on interaction between two or more people. The current study tests the role that synchronization can play in affiliative behavior when interaction is with sound alone, to establish whether the attribution of agency to sound is sufficient to encourage affiliative behavior. While a number of indices of “affiliative behavior” have been used in research of this type, the current experiment uses one specific correlate of trust.

Synchronization and affiliation

Synchronizing movements with another person is an easy act for humans to perform but separating out the features of this act makes it clear why we might expect a positive relationship to exist between synchronization and affiliative behavior. Hagen and

Bryant (2003) suggest theoretical reasons why musical interaction might influence interpersonal relationships, which can be extrapolated to other forms of synchronized movement. Successful synchronization involves the *motivation* to act together, *prediction* of others' behavior (Hove, 2008; Sebanz, et al., 2006), and the act of *moving at the same time*, which may blur self-other boundaries (Sebanz, et al., 2006; Sommerville & Decety, 2006). These can all act as forms of pro-social behavior, so engaging in them might encourage a sense of social closeness with someone with whom we have synchronized.

Mimicry is thought to have a two-way causal relationship with affiliative behavior (Chartrand & Bargh, 1999; Chartrand, Maddux, & Lakin, 2005; Lakin, Jefferis, Cheng, & Chartrand, 2003), and mimicking a co-actor can increase the chance of a positive outcome during negotiation (Maddux, Mullen, & Galinsky, 2008), suggesting that trust is increased as a consequence of this behavior. These effects have been shown to transfer to interaction with virtual agents (Bailenson & Yee, 2005), even in the absence of visual contact with an interaction partner (Swaab, Maddux, & Sinaceur, 2011), and similar links may be found between synchronization and affiliation.

With regards to synchronization it is reported that people tend to drift into synchronized movements with others (Issartel, Marin, & Cadopi, 2007; Kirschner & Tomasello, 2009; Oullier, De Guzman, Jantzen, Lagarde, & Kelso, 2008), even when it requires effort to go against the natural speed of a moved object (Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007), but that social cues can moderate this tendency (Miles, Griffiths, Richardson, & Macrae, 2009; Miles, Lumsden, Richardson, & Macrae, 2011). Objects that are synchronized are likely to be judged as more entitative (Lakens, 2010), and more closely affiliated with one another (Hagen & Bryant, 2003; Miles, Nind,

& Macrae, 2009). Synchronizing activities may be beneficial to the performance of other tasks performed with a partner during (Macrae, Duffy, Miles, & Lawrence, 2008; Miles, Nind, Henderson, & Macrae, 2009; Tsai, Kuo, Jing, Hung, & Tzeng, 2006), and following synchronization (Valdesolo, Ouyang, & DeSteno, 2010). Synchrony with music can also influence affiliative behavior towards another person (Demos, Chaffin, Begosh, Daniels, & Marsh, 2012).

The term synchronization implies two different things: achieving a stable phase relationship with some stimulus, and moving at the same time as it. While in-phase synchronization requires both of these, it is possible to co-ordinate movements with some stimulus without moving at the same time as it. Anti-phase synchrony (i.e. with a phase shift of 0.5) is a less stable strategy than in-phase synchrony, but can also demonstrate stability (e.g. Amazeen, Schmidt, & Turvey, 1995; Schmidt & O'Brien, 1997). If motivation to act together and prediction of the behavior of a co-actor are the only elements required to increase social closeness felt towards them, we might expect other degrees of phase-lock (and anti-phase synchrony in particular) to demonstrate a relationship with measures of affiliative behavior. Two recent studies showed that while in-phase synchronized activities had the effect of blurring “self-other” boundaries, this effect was not apparent in anti-phase synchronization (Macrae, et al., 2008; Miles, Nind, Henderson, et al., 2009). This result implies that the development of a stable phase relationship with some rhythmic stimulus, and in-phase synchronization with that stimulus are perceived differently.

In terms of a causal relationship between synchronization and affiliation, it has been shown that more synchronization with a partner can lead to higher ratings of their

likeability (Hove & Risen, 2009), more co-operation with them in a trust-related economic game (Wiltermuth & Heath, 2009), and a greater propensity to help them when they are put in a difficult situation (Kokal, Engel, Kirschner, & Keysers, 2011; Valdesolo & DeSteno, 2011). These studies only investigated the role of in-phase synchronization. Only the study by Kokal et al. involved synchronization with movement that could not be visually observed, and this involved a period during which associations could be made between movement of a partner and the sounds used.

Music and the sounds of others

While it is argued here that synchronizing with the sounds of other people is a social phenomenon, one of the archetypes of this type of activity, musical engagement, is often experienced in non-social settings. Most people probably hear music that is transmitted to them indirectly far more often than they hear music being played by an observable person.

An important feature of aesthetic arts may be expression of agency (i.e. purposeful organization by a human agent), meaning resonance for the listener/interpreter is possible (Cinzia & Vittorio, 2009; Freedberg & Gallese, 2007; Godøy, 2003; Molnar-Szakacs & Overy, 2006). Compared with hearing a piece of music thought to have been composed by a computer, music attributed to another person is more likely to engage neural networks associated with theory of mind (Steinbeis & Koelsch, 2009), suggesting that sounds are interpreted in a more “social” way when thought to be organized by an agent than when thought to be created automatically. It is therefore of interest to

determine whether synchronization with sounds that are attributed with agency yet have no learned associations with human movement can elicit a similar affiliative response to synchronized movement that is attended to visually.

Current study

The current study used a within-subject design that required participants to synchronize with a number of computer-controlled partners, followed by a measure of trust for each partner. If effects of synchronization are found on affiliative behavior using this paradigm it provides evidence that the attribution of agency to sound is sufficient to induce effects relating to interactive behavior. This approach also removes additional factors that may influence judgment (such as a partner's appearance), and joint attention, which is arguably a precursor to social interaction (Sebanz, et al., 2006).

An indirect measure of affiliative behavior was used: an iterated version of the trustee game (Berg, Dickhaut, & McCabe, 1995). This economic game allows the first player to place trust in a partner, in the form of an economic investment, which may be reciprocated or not. It has been used extensively (a recent meta-analysis looked at 162 replications: Johnson & Mislin, 2011) under the assumption that higher contributions relate to higher levels of trust. Social connections between players, even when manipulated by experimenters immediately prior to the game, can induce players to give higher contributions to one another (Buchan, Johnson, & Croson, 2006; Glaeser, Laibson, Scheinkman, & Soutter, 2000). In our study, participants only obtain information about their partner during tapping, and we expect their experience of this to influence their

sense of social closeness to their partner, which in turn affects the contributions they make in the economic game. Iterated versions of games such as this provide the opportunity for players to build up rapport (e.g. Cochar, Van, & Willinger, 2004), and using genuine monetary compensation gives people the incentive to perform “honestly” (i.e. to attempt to maximize their profit). In order to minimize the possibility of demand characteristics we did not incorporate subjective reports about trust, or other correlates of affiliation, but another study from our group (forthcoming) does confirm that subjective measures demonstrate convergent results.

Giving the instruction not to synchronize in some trials meant we could investigate phase lock other than in-phase using objective measures. Synchronization can be analyzed both in terms of the establishment of stable phase relationships and more precise matching of perceived and produced movement.

It was thought that success in the tapping task might also play a role in the way that participants behave. According to the “warm glow of success” hypothesis (Isen, 1970), increased success in any task can lead to greater generosity (e.g. in an economic game task), helpfulness and attentiveness to a partner. A recent rhythmic tapping experiment suggested that experience of failure may have the opposite effect (see Kurzban, 2001). In the current study, success and synchronization were expected to demonstrate some co-dependence and were not treated as being open to orthogonal manipulation, but experience of task success was controlled by changing the way the computer partner behaved, and subjective experience of this was taken into account using self-reports.

Objective measures of synchronization and participants' subjective experiences of synchronization (measured by self-rating) were used to test the hypothesis that synchronization with sound attributed with agency could affect contributions made in the economic game (the dependent variable). It was expected that after accounting for positive effects of perception of success (measured by self-rating) on contributions made, there would be an additional positive effect arising from synchronization, either due to establishment of a stable phase relationship, or the matching of sound with action. Synchronization was the predictor variable of primary interest, but success was also examined to establish whether it has an additional influence on contributions.

Methods

Participants

41 students and staff were recruited from the University of Western Sydney, and were each paid \$20 for their participation. Three participants were excluded because they identified the aims of the experiment (i.e. during debriefing they reported thinking the aim of the study was to investigate how synchronization in the tapping task affected trusting behavior in the economic game), and were replaced in order to maintain roughly counterbalanced groups. The final sample included 38 participants (12 male, age range 17-46; mean age 22.5).

Procedure

Participants were told the experiment was about interactive games, and they would be interacting with four partners in a tapping game and economic game (Table 1 outlines the experimental procedure). Although participants were led to believe they were interacting with other people, all “partners” were virtual (controlled and sequenced by Max/MSP software v.5.0.8, running on a Mac Book Pro), and performed according to proscribed algorithms.

Tapping game. In the tapping game, participants heard tones over Sennheiser HD 650 headphones (played via an Edirol UA-25 Soundcard) corresponding to the taps of their partner, and were told to play along using a Roland Handsonic HPD-10 drum pad. With two of the partners they were told to synchronize, and with the other two they were told not to synchronize. It was explained that “don’t synchronize,” meant tap at a different time from the tones they were hearing, but try to maintain regularity and make one tap for each tone heard.

A practice of both of these conditions was given at the start of the experiment using an isochronous pulse. Visual feedback was given for each tap made and participants were only allowed to progress after they had made enough correct taps.

During the tapping game, participants were given no feedback, and could not hear their own taps, apart from the gentle thud of their finger on the drum pad. Each trial ran until the participant had made 96 taps. The tones produced by their “partner” were an anisochronic sequence of synthesized woodblock sounds, with the timing devised similarly to Madison and Merker (2004), using a Kolakoski sequence (Kolakoski &

Ucoluk, 1966) to determine whether to shorten or lengthen each interval from an underlying regularity of 600ms. In all trials, intervals were first modified by 45ms from this 600ms pulse (i.e. intervals were either 555ms or 645ms), and in “increasing isochrony” trials, this interval irregularity decreased by 22.5ms every 32 taps, ending with a 600ms pulse. “Increasing anisochrony” trials increased in interval irregularity by 22.5ms every 32 taps.

The four conditions are summarized in Table 2. Anti-phase tapping was expected to develop in the condition with increasing isochrony and instruction not to synchronize. The set of conditions was intended to lead to varied experiences of success and synchronization.

Questionnaire. After each trial of the tapping game, participants answered a brief questionnaire about their perception of the interaction using ratings from 1-7. The two questions of importance were:

1. How synchronized were you with your partner? (Less synchronized – More synchronized)
2. How successful were you at the task? (Less successful – More successful)

In the “don’t synchronize” conditions, an additional guideline was added to the start of this question: “given that your aim was NOT to synchronize,”. As other questions were highly correlated in pilot versions of the study and were not of primary interest, these were not analyzed further.

Trustee game. Following the questionnaire, each participant played two rounds of the trustee game (Berg et al, 1995) with their current partner. A standard algorithm determined the computer response to their contribution (see Figure 1).

Participants were told that each token earned in the economic game would be exchanged for 10c at the end of the experiment, and that they would earn between \$10 and \$20 for their participation. *All* participants ultimately received \$20 for participating, in line with the requirements of the University of Western Sydney ethics committee.

Debriefing. After finishing interaction with all four players, participants were asked who their favorite player was, what they thought the experiment was about, and whether they believed they were interacting with other people.

Analysis

In order to objectively quantify the amount of synchronization participants achieved, two commonly used measures (e.g. Kirschner & Tomasello, 2009; Konvalinka, Vuust, Roepstorff, & Frith, 2010; Tognoli, Lagarde, DeGuzman, & Kelso, 2007) were calculated using circular statistics (Mardia & Jupp, 2000, p. 15). The synchronization index (“R” in circular statistics) gives an indication of synchronization strength regardless of phase and can range from 0 to 1, with higher values generally suggesting greater stability between tap and tone times. The mean circular asynchrony (“ α ” in circular statistics), measures the mean distance between tap and tone times, and here ranges from

- π to π in radians (-180° to 180°) in conditions where participants were told to synchronize, and 0 to 2π (0° to 360°) in conditions where participants were told not to synchronize, with values closer to zero suggesting tap and tone times closer together, and values close to $\pm\pi$ suggesting tap times occurring halfway between tone times. For use in linear models, the synchronization index values were normalized using an arcsine transformation. Mean circular asynchronies were not used in linear models because of their circular nature.

Linear models were adopted so that the ordinal values representing synchronization and success could be used to predict contributions made in the economic game. Using mixed-effects it was possible to include different intercepts and gradients for each individual (e.g. Gelman & Hill, 2007), effectively controlling for intersubject variability. Models tested were of the type:

$$Y = \alpha + \beta X + \gamma Z + \alpha_i + \beta_i X_i + \gamma_i Z_i + \varepsilon$$

where Y is the dependent variable to be modeled (contribution made), α is the intercept term, X and Z represent predictors (e.g. synchronization index, and rating of success), and β and γ are coefficients for the gradients of those terms. Subscript i indicates a vector representing each individual (e.g. α_i is a Gaussian distribution of 38 intercepts, one for each individual). ε is a residual error term. Fixed effects of the model are those given by α , β and γ , while the values α_i , β_i and γ_i are described as the random effects.

The first contribution, and total contribution made in the economic game were modeled separately as these might be indicative of different aspects of trust. Models were

built up in a stepwise manner, providing the normalized synchronization index and ratings of success and synchronization as predictors, and allowing the intercept and the gradient for each predictor to vary between individuals. A random intercept for each individual was always included, to account for individual differences in response to the economic game.

The statistical program R was used to fit and test the models, using package lme4 (Pinheiro & Bates, 2000) with REML (restricted maximum likelihood) fitting to determine the best fit for each model, and log-likelihood comparisons to determine the best model for each dependent variable. The most parsimonious (using Bayesian information criterion) models are given here. Confidence intervals (CI) and *p*-values were calculated using STATA v.12, because these values cannot be estimated in lme4 when random effects are correlated.

Results

A summary of raw data is provided in Figure 2. Ratings of success were higher in both conditions where the computer produced increasingly isochronous tones, and synchronization was rated highest in the condition of synchrony with increasing isochrony. Technical problems meant that questionnaire data were not recorded in one trial for four participants, and tapping data were not recorded in one trial for two participants. During debriefing, when asked about their favorite player, 14 participants said they didn't have one, and 10 said their favorite was the last player, suggesting general recency effects unrelated to the task.

Linear modeling results

For the first contribution, the best fitting model includes ratings of success as a predictor ($\beta = 0.23$, $t = 2.1$, $p = 0.033$, 95% CI [0.018-0.44]) and a random intercept for each individual (see Table 3), although models with ratings of synchronization and a random intercept were similarly good ($\beta = 0.20$, $t = 2.2$, $p = 0.030$, 95% CI [0.020-0.39]), with a BIC difference between the models of 0.1, which is insignificant. Neither adding order effects (using nesting) nor nesting participants according to whether they believed they were interacting with another person improved these models. The computed synchronization index (as opposed to perceived synchronization) did not act as a significant predictor of the first contribution in any model tested, suggesting that phase lock experienced in each trial did not affect the way that participants behaved towards their partner in the economic game.

For total contribution made, the best model includes ratings of success ($\beta = 0.49$, $t = 2.2$, $p = 0.027$, 95% CI [0.056-0.93]) and ratings of synchronization ($\beta = 0.35$, $t = 2.5$, $p = 0.014$, 95% CI [0.072-0.63]) as predictors, and involves a random intercept for each individual, and random gradient for success rating for each individual (details in Table 4). Random effects were negatively correlated (correlation coefficient -0.85) in this model, but restricting their possible values to stop this correlation resulted in an inferior model, so this was rejected. The synchronization index again did not act as a significant predictor of the contribution measure in any model tested. Adding order effects did not improve the model, nor did nesting participants according to whether they reported believing they

were interacting with another person. Figure 3 depicts the fixed effect components of this model, while Figure 4 plots the random effects for three individuals.

In summary, these models suggest that both ratings of success and ratings of synchronization acted as predictors for contributions made, while the synchronization index was not a useful predictor of contributions.

Do objective measures of synchronization predict contributions?

The synchronization index was further assessed to determine whether it could be relevant in particular conditions. In order to generalize across participants' behavior in the economic game, standardized contributions were calculated using z-scores within each individual. Trials in which participants did not correctly follow the instruction given (as assessed by the mean circular asynchrony) were excluded (20 trials out of 150).

In the conditions in which participants were given the instruction to synchronize a significant positive Spearman's correlation exists between the synchronization index and both standardized contribution measures (First contribution $\rho = 0.36, p = 0.0021, n = 70$; Total contribution $\rho = 0.36, p = 0.0021, n = 70$). In conditions where participants were told not to synchronize, correlations between the synchronization index and standardized contribution measures are not significant (First contribution $\rho = -0.11, p = 0.38, n = 60$; Total contribution $\rho = 0.05, p = 0.71, n = 60$).

The mean circular asynchrony was used as an indicator of the temporal proximity of tap times to tone times, and was tested for a quadratic relationship with standardized participant contributions (given the biphasic form of the results). Tests were done within

each of the four conditions separately (in order to meet assumptions of the test) after exclusion of outliers more than 2 standard deviations from the mean of the mean circular asynchrony. Results were expected to demonstrate a parabolic relationship between asynchrony and contributions, with a peak close to 0 in “synchronize” conditions, and a peak close to π in “don’t synchronize” conditions. Examination of the mean asynchrony data used in this analysis demonstrates values close to 0 in the “synchronize” conditions suggesting that participants tended to tap in-phase (SynchIncIso $M = -0.24$ rad, $SD = 0.26$; SynchIncAnis $M = -0.28$ rad, $SD = 0.34$), and values just below π in the “don’t synchronize” conditions suggesting a tendency towards anti-phase tapping (DontIncIso $M = 3.1$ rad, $SD = 0.38$; DontIncAnis $M = 2.9$, rad $SD = 0.5$), with higher variability in the increasing anisochrony conditions. A significant quadratic relationship between mean asynchrony measures and contributions was only found in the condition where participants were told to synchronize and experienced increasing isochrony in the stimuli. Here, the square of the mean circular asynchrony was a significant predictor of the standardized first contribution ($\beta = -2.52$, adjusted $R^2 = 0.20$, $p = 0.0060$, $n = 32$), producing a parabola as expected.

These results suggest that stable phase did relate to the contributions made, but only in the “synchronize” conditions. Proximity of tap and tone times only demonstrated a relationship with first contribution in the “synchronize” condition with increasingly isochronous stimuli. A quadratic relationship did not exist between mean circular asynchrony and contribution measures in the “don’t synchronize” conditions, suggesting that more accurate anti-phase synchronization did not influence contributions made.

Discussion

Results suggest that when synchronizing with sound alone, perceived synchronization can play a role in affiliative behavior, as measured by an economic game. Task success also played a significant role in the way that people approached the economic game, suggesting that it is an important factor to control in future studies and to explore further. Objective measures of synchronization only related to trust in cases where participants had been told to synchronize.

The role of perceived success

In this experiment experience of success played a role in determining contributions in the economic game. After experiencing successful interaction during the tapping task it is likely that participants would feel more positive, and it is already known that success in any task can lead to greater generosity (Isen, 1970). Although synchronization is generally less of an overt individual goal in natural settings (compared with in this controlled experiment), it is possible that feelings of success do play a role in encouraging affiliative behavior in instances of interpersonal co-ordination. In the current study, ratings of success were high in conditions in which the computer partner became increasingly isochronous. There are a number of reasons why this should be the case, including the possibility that participants associated their own success with the good performance of their partner. Manipulating success by informing participants that a partner has different goals would be a way to further explore how success can be

experienced as both a collective and individual phenomenon, but that is beyond the scope of the current study. Here, it was sufficient to ensure that the effects of synchronization could not be fully explained by differences in perception of success.

The role of perceived synchronization

The total contribution demonstrated the hypothesized effect of synchronization after accounting for the influence of success. The relationship between perceived synchronization and contributions made in the economic game suggests that participants judged their partner differently according to their beliefs about how coordinated they had been, and this is in line with previous research suggesting that people who move together are likely to exhibit affiliative behavior toward one another (Hove & Risen, 2009; Kokal, et al., 2011; Valdesolo & DeSteno, 2011; Wiltermuth & Heath, 2009). The convergence of results from research using different measures of affiliative behavior suggests that there is some core feature of affiliation that is being affected by synchronization, and forthcoming work from our group has used a rating scale as an additional subjective measure of affiliation to further support this claim.

In particular, the current study demonstrates that synchronization with sound alone, in the absence of visual cues about the movement of another person, was sufficient to induce feelings of trust. Other studies testing the role that synchronization can play on trust have looked at matching movements, as well as matching timing (e.g. walking in time, or tapping in time), so participants have the opportunity to relate their own movement to actions of a partner that closely resemble their own. It has been suggested

that this act of matching perceived and enacted motion could be the core to establishing affiliative relations when mimicking or synchronizing movement (Sebanz, et al., 2006). However, in the current study there is no direct mapping of perceived *movement* onto action, but sounds were mapped onto action instead. This means participants were interpreting the sounds that they heard, and by ascribing them to another person whom they believed to be making similar movements, were relating the sounds to their own motor activity. There is already evidence to suggest that the perception of sounds that are related to particular movements can engage similar neural networks as those involved in the movement itself (e.g. Aziz-Zadeh, Iacoboni, Zaidel, Wilson, & Mazziotta, 2004; Caetano, Jousmäki, & Hari, 2007; Lahav, Saltzman, & Schlaug, 2007), so the current finding extends the possibility that people enact the movements of others purely based on their sounds to suggest that this might affect the way they later judge those others.

Subjective measures of anti-phase synchronization were not used in the current study because it would require additional training for participants to recognize this state. However, using objective measures of synchronization it was possible to assess whether experience of anti-phase, and other forms of synchronization, could relate to the measure of trust.

The role of objective measures of synchronization

Two objective measures of synchronization were tested for a relationship with contributions in the economic game. The synchronization index indicates temporal stability established between tap and tone times, while the mean circular asynchrony

indicates how far tap times were from tone times on average, and can therefore be used to assess how close participants were to accurate in-phase and anti-phase synchronization.

While the synchronization index did not predict behavior in the economic game overall, it did have a positive relationship with contributions in the conditions in which synchronization was the goal. This is in keeping with results suggesting there is less of a psychological connection experienced during anti-phase, compared with in-phase synchronization (Macrae, et al., 2008; Miles, Nind, Henderson, et al., 2009). This is most likely because asynchronies between tap and tone times are far greater when moving out of time, making it harder to gauge the temporal stability. The relationship reported between the synchronization index and contributions coincides with participants' experience of success in this condition, so this result should be interpreted as potentially the combination of both objective synchronization, and subjective experience of success.

Similarly, the expected relationship between mean circular asynchrony and a contribution measure was only found in the condition in which participants were told to synchronize and experienced increasing isochrony, which is arguably the most straightforward condition, meaning in this case the objective measure might best reflect the subjective experience of participants. The mean asynchrony data assessed for this relationship did demonstrate a tendency towards anti-phase synchronization in "don't synchronize" conditions, but participants who were closer to this most stable strategy did not contribute relatively more.

The impact of believing interaction was with another person

While developing the current paradigm it was important to determine whether participants believed that they were interacting with another person or not. In the current sample the same number of the participants reported believing that they were interacting with people as reported believing they were interacting with a computer. This is a relatively large proportion compared with pilot testing. Using these subjective reports as a grouping level for individuals did not improve linear models, meaning there was no significant tendency for individuals who believed they were interacting with another person to behave more similarly to one another than people who did not believe this. If participants were aware that there is a formulaic response (i.e. believed they were interacting with a computer), there would be no incentive to judge their partner, and make offers based on this judgment (e.g. Mikolajczak, et al., 2010), so we would expect no relationship between the contributions made and the tapping task. Since there does not appear to be any such distinction between the groups reporting different beliefs about their partners, the post-test questionnaire is likely to be an ineffective way of determining belief about the type of partners involved in interaction.

Conclusions

These results suggest that perceived synchronization with sounds triggered by others can affect the way that we judge them. By removing social contact in this experiment we have taken away many possible confounding factors, and still found that the hypothesized relationship exists. Objective measures of synchrony were only shown

to relate to trust when people were tapping in-phase, and it is likely that during anti-phase movement people were less likely to detect and reflect on the synchrony achieved.

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Table 1

Order of Whole Procedure

Player	Task	Approximate Time to Complete (minutes)
	Participants are given instructions, give consent to participate	5
	Practice tapping game (“Synch” followed by “Don’t synch”)	3
	Practice economic game	2
	Practice tapping game (type depends on following player type)	1
1	Tapping game	2
	Fill in questionnaire	1
	Economic game x 2 rounds	1
	Practice tapping game (type depends on following player type)	1
2	Tapping game	2
	Fill in questionnaire	1
	Economic game x 2 rounds	1
	Practice tapping game (type depends on following player type)	1
3	Tapping game	2
	Fill in questionnaire	1
	Economic game x 2 rounds	1
	Practice tapping game (type depends on following player type)	1
4	Tapping game	2
	Fill in questionnaire	1
	Economic game x 2 rounds	1
	Debriefing	5

Table 2

Experimental Conditions

Instruction	Computer Condition	Predicted Perception	
		Synchrony	Success
Synchronize	Increasing isochrony	In-phase	Yes
	Increasing anisochrony	No synch	No
Don't	Increasing isochrony	Anti-phase	Yes
Synchronize	Increasing anisochrony	No synch	Yes

Table 3

Random Effects of First Contribution Models

Participant	Coefficient of Intercept for Success Model ($\alpha + \alpha_i$)	Coefficient of Intercept for Synchronization Model ($\alpha + \alpha_i$)
AB	5.4	5.6
AC	4.5	4.6
AD	5.0	5.3
AE	5.3	5.5
AF	6.2	6.2
AG	5.4	5.7
AI	7.0	7.1
AJ	4.0	4.0
AM	3.7	4.1
AN	3.1	3.2
AO	4.1	4.4
AP	3.4	3.6
AQ	0.71	1.5
AR	5.4	6.0
AT	6.3	6.8
AU	3.8	4.5
AV	3.1	3.4
AW	3.1	3.2
AZ	5.8	5.9
BA	5.8	6.3
BC	7.0	7.0
BE	4.9	5.6
BF	7.6	7.7
BG	3.9	4.2
BH	5.6	5.9
BI	4.9	5.1
BK	7.6	6.7
BL	3.9	7.1
BM	5.6	5.3
FA	4.9	5.0
FD	6.6	5.3
FF	6.9	6.5
FG	5.3	3.8
FH	4.8	3.7
FI	4.8	5.0
FJ	6.2	3.9
FK	6.5	7.0
FL	5.5	5.6

Table 4

Random Effects of Total Contribution Model

Participant	Coefficient of Intercept ($\alpha + \alpha_i$)	Coefficient of Success Gradient ($\beta + \beta_i$)
AB	10	0.29
AC	7.5	0.38
AD	11	-0.052
AE	11	-0.10
AF	16	-0.18
AG	6.4	1.1
AI	18	-0.37
AJ	6.0	0.54
AM	6.0	0.43
AN	2.1	0.88
AO	6.6	0.55
AP	1.5	1.1
AQ	3.3	-0.062
AR	14	-0.26
AT	14	0.13
AU	6.5	0.51
AV	3.1	1.0
AW	2.8	1.0
AZ	11	0.40
BA	17	-0.64
BC	6.8	0.88
BE	-3.7	2.5
BF	19	-0.43
BG	8.0	-0.16
BH	7.9	1.1
BI	4.9	0.64
BK	13	0.22
BL	15	-0.11
BM	8.9	0.57
FA	4.2	1.3
FD	7.4	0.73
FF	12	0.43
FG	4.3	0.82
FH	5.0	0.96
FI	7.0	0.99
FJ	4.2	0.99
FK	14	0.31
FL	11	0.26

Figure 1. Trustee game computer response. A: Table of responses made by computer in first round. In the second round, the computer would decrease these contributions by 1 if participants decreased their own contribution, or increase them by 1 in every other case. B: Worked example demonstrating participant and computer credits (at top and bottom) throughout the exchange. Exp is experimenter.

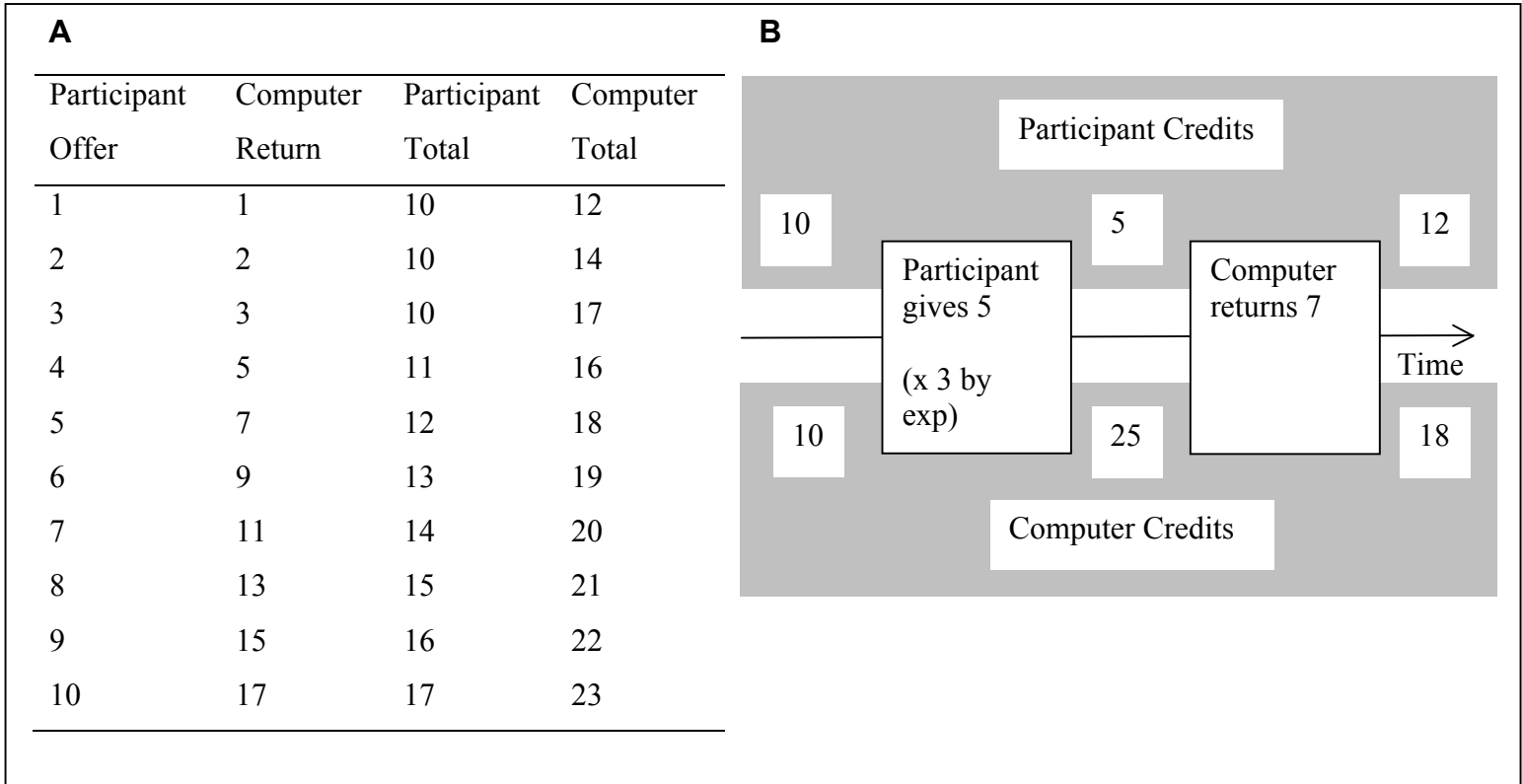


Figure 2. Bar charts give mean ratings of synchronization and success, and first and total contribution measures by condition. Conditions are described by “Synch”, meaning the instruction was to synchronize, or “Dont”, meaning the instruction was to not synchronize, and “IncIso”, meaning the stimuli became increasingly isochronous, or “IncAnis” meaning the stimuli became increasingly anisochronous. Error bars give standard error.

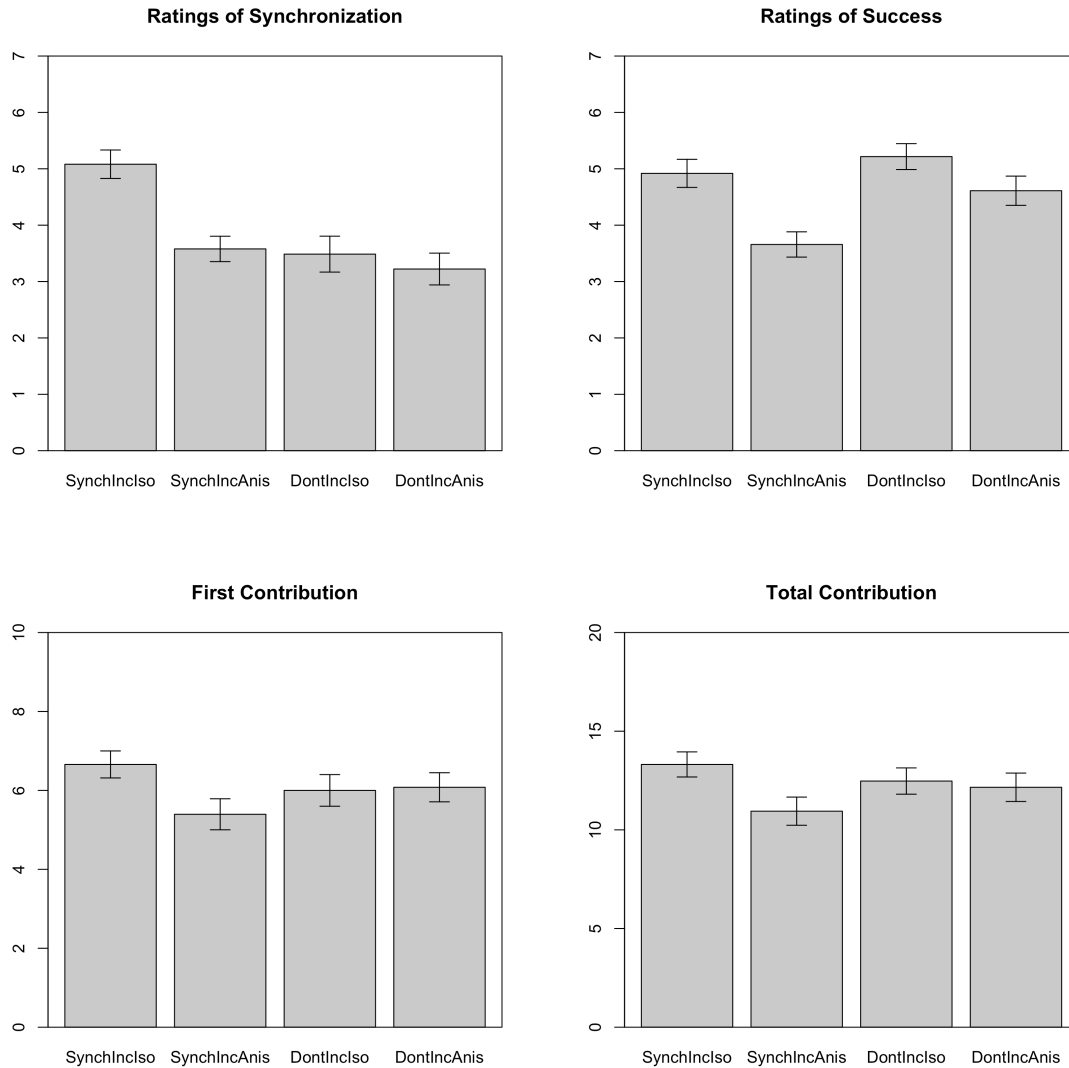


Figure 3. Fixed effects linear model for total contribution. Plane indicates line of best fit, using ratings of success and synchronization as predictors.

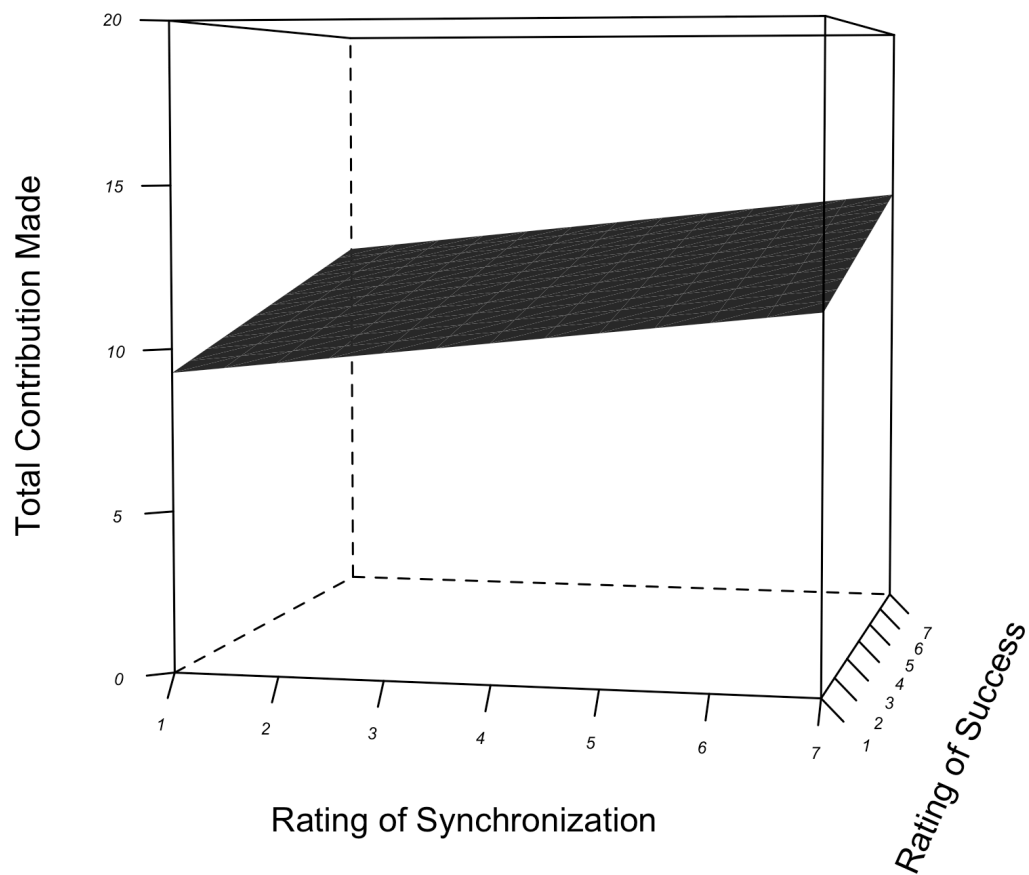


Figure 4. Examples of random effects. Data points and gradient corresponding to random effects model for the role success played on total contribution for 3 individuals: two with the most extreme negative and positive gradients, and one individual with a slope more closely matched to the fixed effects (“BA”, “BE”, and “AC”).

