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Articulatory Constraints on Interpersonal Postural Coordination

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Cooperative conversation has been shown to foster interpersonal postural coordination. The authors investigated whether such coordination is mediated by the influence of articulation on postural sway. In Experiment 1, talkers produced words in synchrony or in alternation, as the authors varied speaking rate and word similarity. Greater shared postural activity was found for the faster speaking rate. In Experiment 2, the authors demonstrated that shared postural activity also increases when individuals speak the same words or speak words that have similar stress patterns. However, this increase in shared postural activity is present only when participants' data are compared with those of their partner, who was present during the task, but not when compared with the data of a member of a different pair speaking the same word sequences as those of the original partner. The authors' findings suggest that interpersonal postural coordination observed during conversation is mediated by convergent speaking patterns.

Keywords: interpersonal coordination, postural control, recurrence analysis, speech

As social agents, we coordinate our movements with those around us. Whether we need to ask another person for directions or lift and move objects with a coworker, this coordination enables us to accomplish successfully many of the activities that we perform every day. Interestingly, the coordination that occurs between interacting individuals is not always deliberate and can often occur spontaneously. In a growing body of research, authors have demonstrated this by showing that interacting individuals spontaneously coordinate or mimic one another's postures (Bernieri & Rosenthal, 1991; Charney, 1966; Chartrand & Bargh, 1999; LaFrance, 1982; LaFrance & Broadbent, 1976), mannerisms (Chartrand & Bargh, 1999), facial expressions (Bavelas, Black, Lemery, & Mullett, 1987; Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977; Provine, 1986; Strack, Martin, & Stepper, 1988), and limb movements (Richardson, Marsh, & Schmidt, 2005; Schmidt & O'Brien, 1997).

Although much of the spontaneous coordination that occurs between interacting individuals requires that the individuals see their co-actor's movements, visual information is not the only medium that couples the movements of interacting individuals. The verbal exchanges that occur during a conversation also can operate to couple the movements of interacting individuals. In fact, not only can verbal exchanges operate to entrain the gestural (Furuyama, 2000, 2002; Furuyama, Hayashi, & Mishima, 2005) and postural (Condon & Ogston, 1966; Kendon, 1970; LaFrance, 1982; Shockley, Santana, & Fowler, 2003) movements of interacting individuals without the individuals intending to entrain, but they also can lead to the interacting individuals converging in dialect (Giles, 1973), speaking rate (Street, 1984), vocal intensity (Natale, 1975), and pausing frequency (Cappella & Planalp, 1981; see Giles, Coupland, & Coupland, 1991, for a review).

The most recent evidence demonstrating that verbal exchanges can result in the movements of interacting individuals becoming coordinated comes from an experiment conducted by Shockley, Santana, and Fowler (2003). In their experiment, they examined the amount of postural coordination that occurred between 2 conversing individuals by having participants stand and discuss the subtle differences between a pair of similar cartoon pictures. The pictures were placed on wooden stands at eye level, such that the participants interacted visually and verbally (faced one another and conversed with one another), interacted only verbally (faced in opposite directions), interacted only visually (faced one another but conversed with a confederate), or did not interact with one another at all (faced away and conversed with a confederate). By objectively measuring the participants' postural activity using movement sensors attached to the participants' waists, the investigators demonstrated that the participants' postural activity became entrained only when they were interacting verbally. More specifically, the findings showed that participants exhibited an increased level of shared postural activity when they were conversing with one another, regardless of whether the participants

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had visual information about their co-actor or not. Visual information had no effect on the amount of shared postural activity.

The findings of Shockley et al. (2003) provide clear evidence that the verbal exchanges that occur during conversational speaking can serve as a medium for the interpersonal coordination of postural activity. But what is it about a cooperative speaking task that yields postural coordination? It may be that the coordination of postural sway facilitates solution of the puzzle task. For example, in prior studies, researchers have demonstrated that postural sway is modified to support suprapostural tasks (e.g., touching; Riley, Stoffregen, Grocki, & Turvey, 1999), and looking (Stoffregen, Pagulayan, Bardy, & Hettinger, 2000; Stoffregen, Smart, Bardy, & Pagulayan, 1999; see also Riccio & Stoffregen, 1988).

It may also be the case, however, that the articulatory behaviors or verbal subtasks required for completion of the puzzle task generated the postural entrainment. During the verbal exchanges in the experiment, the pair members typically spoke in an alternating fashion (first one individual speaks and then the other), and their verbal productions had related content. Other research suggests that interlocutors produce compatible rhythms (Couper-Kuhlen, 1993). Further, the articulatory and respiratory processes involved in such verbal productions have postural consequences by virtue of the mechanical linkage of the speech apparatus to the postural system (Conrad & Schonle, 1979; Dault, Yardley, & Frank, 2003; Jeong, 1991; Rimmer, Ford, & Whitelaw, 1995; Yardley, Gardner, Leadbetter, & Lavie, 1999). Thus, it is possible that the turn-taking aspect of the verbal exchanges created the postural entrainment observed by Shockley et al (2003). Alternatively, it could have been a convergence in speaking rate (Cappella & Planalp, 1981; Natale, 1975; Street, 1984) that caused a similar (secondary) convergence in the patterning of the individuals' postural activity. Perhaps it was the postural consequences of the individuals converging in their vocal utterances that created an increase in the amount of shared postural activity. Or perhaps the postural entrainment observed by Shockley et al. (2003) was a secondary effect of the individual's postural movements entraining to the vocal patterns or rhythms latent within a speech signal (Abercrombie, 1967). This latter possibility would be consistent with research demonstrating that the postural movements of an individual can entrain spontaneously to environmental rhythms (Dijkstra, Schöner, & Gielen, 1994; Dijkstra, Schöner, Giese, & Gielen, 1994; Jeka, Oie, Schöner, Dijkstra, & Henson, 1998; Jeka, Schöner, Dijkstra, Ribeiro, & Lackner, 1997).

In the current study, we investigated these possibilities in two experiments. Two participants stood on either side of a visual partition and produced words presented to them on separate monitors. By having the participants speak the words at the same time or in alternation and at a slow, fast, or natural (jointly selected) tempo, we investigated whether the postural coordination that occurs between verbally interacting individuals is a function of the temporal dynamics of conversational speaking. More specifically, we designed the experiments to determine whether speaking rate (slow versus fast) or the turn-taking nature of conversational speech production underlies shared postural activity. By including the natural speaking rate condition, in Experiment 1 we also examined whether a natural convergence in speaking rate (Cappella & Planalp, 1981; Natale, 1975; Street, 1984) is responsible for causing a similar (secondary) convergence in the patterning of postural sway. The similarity in the stress patterns of the words that participants produced also was manipulated in Experiments 1 and 2 and involved individuals speaking the same words, different words that had the same stress pattern (e.g, *donut, easy*), or different words that had a different stress pattern (e.g., *about, easy*). We included this word-similarity manipulation to test whether the postural coordination observed by Shockley et al. (2003) was an artifact of the speakers producing the same words while conversing.

In both experiments, we recorded participants' postural activity by attaching a movement sensor to their waists. Given the nonstationarity of postural sway time series data (e.g., Carroll & Freedman, 1993; Collins & De Luca, 1993), we determined the postural entrainment that occurred between the 2 interacting individuals in each pair of participants using the same technique as that used by Shockley et al. (2003), namely, *cross-recurrence quantification (CRQ) analysis*. CRQ is a nonlinear technique that enables researchers to determine the dynamic similarity of system trajectories without making any assumptions about data size, distribution, or stationarity. It involves determining recurrent states in reconstructed phase space and is known to be highly sensitive to the subtle space–time correlations that can occur between two motion trajectories (see Marwan, 2003; Shockley, Butwill, Zbilut, & Webber, 2002; Shockley et al., 2003; Zbilut, Giuliani, & Webber, 1998; for tutorials, see Shockley, 2005, and Webber & Zbilut, 2005). This sensitivity makes CRQ an ideal tool for analysis of the postural entrainment that occurs between two interacting individuals (Shockley et al., 2003). Although CRQ results in a number of different statistics (see, e.g., Webber & Zbilut, 2005; see Marwan, 2003, for a detailed discussion of these statistics), the *percentage of states in the two movement trajectories that are recurrent (close together) in the reconstructed phase space* (*%REC*) and the maximum number of consecutive states that remain close together over time and form a sequence or line of recurrent states (*MAXLINE*) are most relevant for the determination of postural entrainment. They capture the amount (%REC) and stability (MAXLINE) of the shared postural activity and, thus, increase in magnitude when the amount of shared postural activity increases and when the postural movements of two interacting individuals become entrained.

Experiment 1

We designed the present experiment to investigate the influence of speaking alternation pattern (speaking in alternation vs. speaking together), speaking rate (slow, fast, or at a self-selected pace), and word similarity (same words, different words with same stress pattern, different stress pattern) on shared postural activity of pairs of speakers.

Method

Participants. Seventy-two undergraduate or graduate students (45 women, 27 men; M = 19.99 years, SD = 2.54 years, range = 14 years) from the University of Cincinnati participated on a voluntary basis. We paired the participants to form 36 participant dyads. There were 17 mixed-gender pairs, 14 female pairs, and 5 male pairs. Twelve pairs of participants were placed in 1 of 3 word similarity groups. Pair members produced the same words (S), produced different words but words that had the same stress (DS), or produced different words with different stress (DD). No participant had a medical history of diseases or recent injuries that would affect balance, and all participants had normal or corrected-to-normal vision.

Apparatus. Postural sway was recorded in the anterior–posterior (A–P) direction at a sampling rate of 60 Hz through use of a magnetic motion tracking system (Polhemus Fastrak; Polhemus Corporation, Colchester, VT) and 6-D Research System software (Skill Technologies, Phoenix, AZ) running on a PC. One sensor, which was affixed to a Velcro belt around each participant's waist, measured postural sway. Participants stood side by side on the same side of the magnetic field emitter, each standing approximately 90 cm from the emitter.

We presented words visually using Microsoft PowerPoint on two 36.8 cm × 25.4 cm LCD monitors (resolution 1024 × 768 pixels); one monitor was positioned at eye height in front of each participant. As shown in Figure 1, the monitors were placed side by side on a two-tier metal cart measuring 1.65 m from the floor to the top of the monitors. Pair members stood on either side of a 97.79 cm × 71.12 cm cardboard partition, which we placed between the two monitors and extended to the shoulders of the participants to ensure that each participant viewed only the monitor in front of him or her and to ensure that participants could not see one another's head and torso. Each participant stood approximately 105 cm from the monitor. Material was displayed on the monitor through use of 60-point font.

Procedure. Each participant pair completed 18 trials for one of the three experimental conditions. A single trial consisted of a 2-min data collection session. During each trial, the two participants stood upright on either side of the cardboard partition in front of each monitor and were instructed to avoid any gross extraneous movements and to keep their feet shoulder width apart in a specified location. The stimuli were presented visually on the computer monitors and were two-syllable words in which the stress occurred naturally on the first syllable (e.g., *do*nut) or naturally on the second syllable (e.g., a*bout*). Pair members were given the instructions that they should read the words aloud as they appeared on the computer monitor positioned directly in front of them during the 2-min data collection.

For each participant pair, there were two within-participant manipulations of speaking alternation pattern (antiphase or inphase word recital) and speaking rate (slow speed, fast speed, or natural). For a given trial, each participant pair was presented with words in either an alternating fashion (antiphase) or simultaneously (in phase). These words were presented at one of three speaking rate conditions: slow pace (interstimulus interval [ISI] = 2.0 s), fast pace (ISI = 1.2 s), or natural (jointly selected) pace. In the natural speaking rate condition, all of the words for a given trial were presented simultaneously, rather than appearing one at a time, and participants were instructed to read the list at a tempo of their own choice. To control for eye movements in this condition, we presented words in columns for 1 participant and in rows for the other. Accordingly, the participant viewing the words in columns was instructed to read down the columns, whereas the other was instructed to read across the rows. For the antiphase condition, participants were instructed to alternate who spoke each word (i.e., they took turns speaking). For the inphase condition, participants were instructed to utter each word simultaneously.

The 36 pairs were randomly assigned to one of three word similarity conditions. In the S condition, the same word in a given word pair was presented to both participants. In the DS condition, different words were presented to the participants that stressed the same syllable. In the DD condition, different words were presented to the participants that stressed different syllables.

Data reduction. For each trial, displacement (measured in centimeters) of each participant's waist in the anterior–posterior direction was selected as the postural sway time series for analysis (Shockley et al., 2003). We converted these time series into standard (z) scores to achieve a common scale without influencing the distribution of scores within each time series. On the basis of the principles of phase-space reconstruction (Abarbanel, 1996), CRQ requires the embedding of two time series (x and y) in phase space through use of surrogate (time-delayed copies of x and y) dimensions that we created using the same time delay in the respective time series. Overlap of trajectories, $x(i) = y(j)$, within some radius in reconstructed phase space counts as recurrence in CRQ. Several CRQ statistics can be computed. The first statistic, %REC, reflects the proportion of locations in reconstructed phase space at which the pair's movements coincided (i.e., where x and y converge within some radius in phase space). A second statistic, MAXLINE, indexes the stability of shared activity over time as the maximum number of consecutive recurrent data points from x and y. We used these to evaluate the similarity of postural activity between

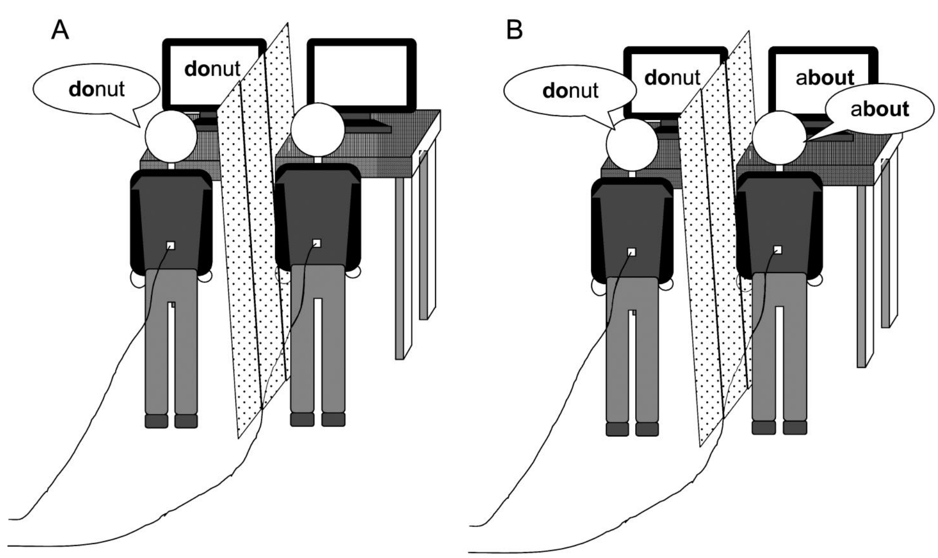

Figure 1. Method used in Experiment 1, depicting speaking alternation patterns. Panel A: Antiphase pattern. Panel B: Inphase pattern. Boldface type depicts the syllable emphasized (but this boldface type was not present in the actual stimuli). Emphasis on the first syllable is depicted on the left side of Panels A and B; emphasis on the second syllable is depicted on the right side of Panel B.

people. For this and subsequent experiments, we used a delay of 25 data points (0.42 s) and 10 embedding dimensions with a recurrence inclusion radius of 30% of the mean distance separating points in reconstructed phase space. These parameters corresponded to those used by Shockley et al. (2003).

Results

Each of the shared postural activity measures of %REC and MAXLINE were submitted to a three-way (Speaking Alternation Pattern × Speaking Rate × Word Similarity) mixed analysis of variance (ANOVA). We found no influence of speaking alternation pattern on %REC or on MAXLINE (Fs < 1), with participants exhibiting the same magnitude of shared postural activity when speaking together (inphase) and when speaking in alternation (antiphase). As illustrated in Figure 2, Panel A, a main effect of speaking rate was found for %REC, $F(2, 66) = 4.66$, $p < .05$. Post-hoc comparisons indicated that participants speaking at the faster rate showed greater %REC (greater shared postural locations) than did those in the slower and natural conditions. There was no difference between the natural and slower speaking rate conditions. There was also a main effect of speaking rate on MAXLINE, $F(2, 66) = 5.20$, $p < .01$ (see Figure 2, Panel B). Post hoc comparisons indicated that participants speaking at the faster rate showed greater MAXLINE (shared postural trajectories stayed parallel longer) than did those in the slower and natural conditions. Again there was no difference between the natural and slower conditions. There was no main effect of word similarity (see Figure 2, Panels C and D) on %REC or MAXLINE, with participants exhibiting the same magnitude of shared postural activity for the S, DS, and DD word similarity conditions. There were no significant interactions (Fs < 1).

Discussion

In the present experiment, we investigated the influence of speaking alternation pattern, speaking rate, and word similarity on nonlinear measures of interpersonal postural coordination. In summary, we found no influence of speaking alternation pattern on shared postural activity measures, nor did we find an influence of word similarity. However, we did find a main effect of speaking rate on shared postural activity (%REC) and on stability of shared postural activity (MAXLINE).

Finding no influence of speaking alternation pattern on indices of shared postural activity must be interpreted with some caution, given that %REC is a time-independent measure. In other words, counting the postural activity of 1 participant as the same as that of a 2nd participant (i.e., considering the two postural configurations to be recurrent) does not require that the postural activity in question occur at the same time. MAXLINE, however, which is sensitive to the sequencing of recurrent points (i.e., it is time dependent), also was not found to be influenced by speaking alternation pattern. The absence of an effect of speaking alterna-

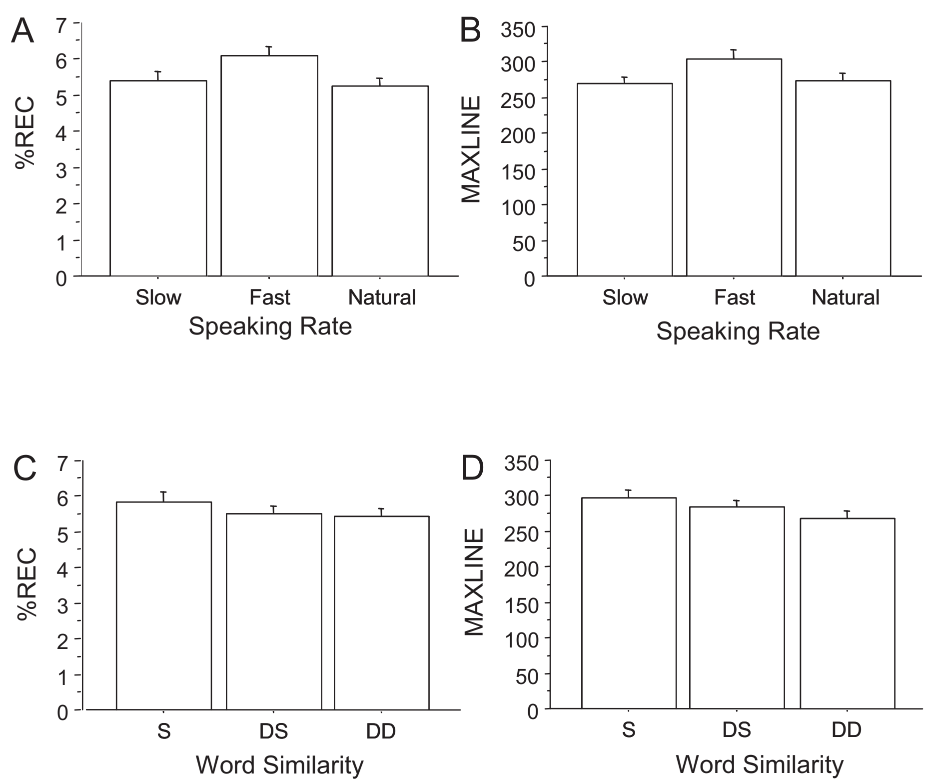

Figure 2. Results of Experiment 1. Error bars reflect standard errors. %REC = percent recurrence; MAXLINE = the maximum number of consecutive states that remain close together over time and form a sequence or line of recurrent states. S = same words; DS = different words, same stress; DD = different words, different stress.

tion pattern combined with the absence of a distinctive influence of the natural speaking rate suggest that the temporal coordination of utterances does not mediate the interpersonal coordination patterns observed by Shockley et al. (2003), provided that the proportion of words uttered is balanced.

Shared postural activity was found to be greater for the faster speaking rate compared with the slower and natural speaking rates. A greater number of words were uttered in the faster condition than in the slower condition—that is, in the slower condition, there is less overall articulation and, therefore, greater opportunity for individual postural trajectories to evolve unconstrained by speaking than in the faster speaking rate condition. The implication is that the biomechanical consequences of speech production (articulatory and respiratory processes; Conrad & Schonle, 1979) constrain the evolution of postural trajectories. This implication is consistent with research by Yardley et al. (1999) and Dault et al. (2003), who found that cognitive tasks involving speaking increase postural sway path length—the Euclidean distance along the transverse plane traversed by the center of pressure at the feet during standing. Jeong (1991) also found that postural sway increases when respiration rate increases. The interpretation for the present experiment is that when 2 persons are speaking in a common task framework, the postural trajectory of each speaker is constrained by the biomechanical process of articulation. Given that each participant in a pair was speaking equally as often as his or her partner, the evolution of the postural trajectories of a participant pair was constrained similarly for the 2 members of a pair. The condition in which participants selected their speaking pace yielded results that were not significantly different than those of the slower conditions. Unfortunately, we did not measure the rate at which the participants spoke in the natural pace condition; thus, we were unable to determine whether the similarity in the magnitude of shared postural activity for the slow speaking rate condition and the natural speaking rate condition was because the participants' natural (self-selected) speaking rate was similar to that of the slow condition. (Our subjective impression was that the natural pace consistently fell somewhere between the slower and faster imposed speaking rate). Despite this omission, finding no difference between the natural speaking rate condition and the slow speaking rate condition does suggest that a self-selection of speaking rate does not facilitate interpersonal postural coordination more than does an imposed pace.

Interestingly, close inspection of the data suggested that individual differences in the overall magnitude of the CRQ measures might have masked any influence of the word similarity manipulation (a between-participants manipulation). That is, participant pairs' mean %REC values ranged from 0.29 to 8.03, yet the mean differences in %REC among the three word similarity conditions only ranged from 4.62 to 5.39. Although the influence of word similarity on %REC and MAXLINE was not significant, the pattern in the means of the three word similarity conditions indicated a trend toward an increase in shared postural activity as the similarity of the words increased (see Figure 2, Panels C and D). Thus, we designed Experiment 2 to further test our hypothesis that shared postural activity would increase with increasing word similarity by making word similarity a within-participants variable.

Experiment 2

In Experiment 1, we manipulated Word Similarity as a between-participants factor and found a nonsignificant pattern in the means, thus suggesting that shared postural activity may increase with increasing similarity of words uttered. In the present experiment, we replicated the Word Similarity manipulation of Experiment 1 as a within-participants factor. As indicated previously, the articulatory processes involved in verbal productions have postural consequences by virtue of the mechanical linkage of the speech apparatus to the postural system (Conrad & Schonle, 1979; Dault et al., 2003; Jeong, 1991; Rimmer et al., 1995; Yardley et al., 1999). Thus, we expected the amount of shared postural activity (%REC) and the stability of shared postural activity (MAXLINE) to increase with increasing word similarity.

Method

Participants. Thirty-four undergraduate or graduate students (20 women, 14 men; $M = 20.65$ years, $SD = 3.41$ years, range = 15 years) from the University of Cincinnati participated on a voluntary basis. We paired the participants to form 17 participant dyads, resulting in 6 mixed-gender pairs, 7 female pairs, and 4 male pairs. No participant had a medical history of diseases or recent injuries that would affect balance, and all participants had normal or corrected-to-normal vision.

Apparatus. The same apparatus and experimental setup used in Experiment 1 were used for this experiment.

Procedure. The same word similarity manipulation described in Experiment 1 was used in this experiment. A within-participants manipulation of word similarity yielded nine 2-min trials in each of the three conditions (S, DS, DD). All word pairs were presented to the participants at the same time (inphase) at a set pace (ISI = 1.5 s).

Results

Shared postural activity measures of %REC and MAXLINE were submitted to a single-factor, repeated-measures ANOVA. One participant pair was excluded from the analysis because the mean %REC in the DD condition was more than 2.5 standard deviations from the mean for that condition. A main effect of word similarity was found on %REC, $F(2, 30) = 5.22$, $p < .05$ (see Figure 3) such that there were more shared postural locations with increasing similarity of words. Post hoc analysis revealed that the

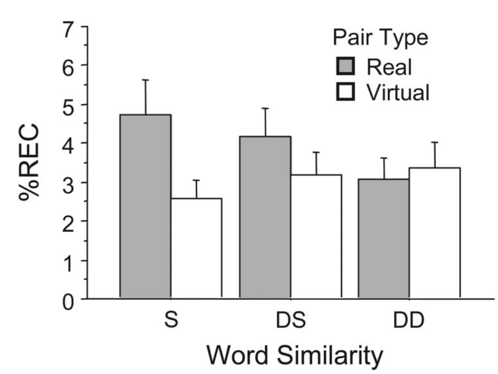

Figure 3. Results of Experiment 2. Error bars reflect standard errors. %REC = percent recurrence. S = same words; DS = different words, same stress; DD = different words, different stress.

DD and DS conditions were significantly different from one another, as were the DD and S conditions, but the DS and S conditions were not significantly different from one another. We observed no main effect of word similarity on MAXLINE, $F(2, 30) = 1.66$, $p > .05$.

To determine whether increases in shared postural activity would be observed regardless of whether the persons speaking were tested at the same time, we created virtual pairs from the existing data set. That is, the postural data from a member of 1 original pair was compared with the postural data from a member of a different original pair who uttered the same set of words. Thus, if the observed interpersonal postural coordination were due to purely articulatory influences, the same pattern of results as that of the original pairs should be observed. Two virtual participant pairs were excluded because the means for %REC were greater than 2.5 standard deviations from the mean for 1 pair's DS condition and the other pair's S condition.

Mean %REC and MAXLINE data were submitted to a 2 (Pair Type) × 3 (Word Similarity) mixed ANOVA. There was no main effect of pair type, $F(1, 29) = 1.18$, $p > .05$, and no main effect of word similarity, $F(2, 58) = 1.15$, $p > .05$. There was, however, a significant interaction between pair type and word similarity, $F(2, 58) = 6.73$, $p < .005$. For the virtual pairs, there was no simple main effect of word similarity on %REC, $F(2, 28) = 2.10$, $p > .05$. For MAXLINE, there was no main effect of pair type, $F(1, 29) = 1.35$, $p > .05$; no main effect of word similarity, $F(2, 58) = 1.23$, $p > .05$; and no interaction, $F(2, 58) = 2.60$, $p > .05$.

Discussion

In the present experiment, we manipulated the similarity of words uttered at a fixed speaking rate in an inphase speaking alternation pattern. As expected, we found that as the similarity of words increased, shared postural activity increased. Unexpectedly, we found no influence of word similarity on the stability of the shared activity. This finding complements the finding in Experiment 1 that the influence of articulation on the evolution of postural trajectories mediates the interpersonal coordination observed by Shockley et al. (2003). The fact that word similarity did not influence how long postural trajectories remained parallel (MAXLINE) but that speaking rate did influence MAXLINE in Experiment 1 may suggest that increasing the amount of articulation (regardless of the similarity of the words they produce) stabilizes postural trajectories' coordinated activity. The present experiment suggests, however, that the evolution of postural trajectories also depends on word similarity. When articulation patterns are more similar across two speakers, the shared postural activity is greater than when the articulation patterns are less similar. This latter finding is consistent with the findings of previous studies in which researchers suggest that the biomechanical consequences of articulatory and respiratory processes of speaking influence postural activity and do so distinctively. Bouisset and Duchene (1994) found an increase in sway amplitude and sway path length during deep breathing compared with quiet breathing. Jeong (1991), likewise, found an increase in postural sway when participants held their breath after inspiration, compared with no increase when they held their breath after expiration. Given the findings of Experiment 1, it would then seem that the particular articulation patterns influence the evolution of the speaker's postural trajectory in particular ways. When members of a participant pair are speaking words that are similar, their postural trajectories, accordingly, evolve in a similar fashion with respect to one another and, thus, yield greater shared postural activity.

The interpretation that the interpersonal postural coordination observed during cooperative conversation results purely from similarity in articulation patterns suggests that the observed postural coordination should be present whenever two speakers are uttering the same articulatory patterns (i.e., the same utterances in the same sequence). To test this, we compared the shared postural activity of virtual pairs: pairings of 1 member of 1 participant pair with a member of a different participant pair uttering the same word sequences as that of the original pair. Surprisingly, we found no significant influence of word similarity on the shared postural sway activity of virtual pairs. The implication is that the articulatory influence is only partially responsible for the coordination of postural sway observed in the original pairing. Simply articulating a particular word sequence of comparable structure does not guarantee that two individuals will exhibit the same evolution of postural sway activity. Rather, the occurrence of shared postural activity between two individuals appears to require that the two individuals be in the presence of one another. This finding is consistent with previous social psychological research that demonstrates how an individual's behavior is influenced by simply the mere presence of another individual (e.g., Latané, 1981; Zajonc, 1965). Moreover, this finding appears to reflect how the formation of a social unit or the existence of a social situation is a necessary condition for the emergence of interpersonal coordination and that the mechanisms that underlie such coordination interact with or are facilitated by other social or interpersonal processes (Marsh, Richardson, Baron, & Schmidt, 2006).

Thus, one possible explanation for the finding that shared postural activity increased when members of a pair were in the presence of one another but did not increase when they were not in the presence of one another is that, despite that speaking was paced by the presentation rate of the words on the computer monitor, the timing of the articulation of 1 member of a pair still influenced the articulation timing of the other member. That is, instead of simply reading a word as quickly as it appeared on the computer screen regardless of when the other participant was speaking, the 2 participants may have spontaneously coordinated the timing of their responding beyond the timing constraints of the visual presentation. This strategy would be effective, for example, in avoiding any disruptive influence of hearing another speaker while trying to read a word aloud. It is important that we qualify this interpretation. If the timing of the responses across members of a pair was coordinated, the timing itself is unlikely to be the source of the coordination in posture because the %REC increased with increasing word similarity. Instead, the coordinated timing would appear to be a precondition to revealing the biomechanical influence of uttering words of varying similarity on shared postural activity.

Conclusion

In two experiments, we found that increases in speaking rate and increases in the similarity of words spoken increased the shared postural activity between participant pairs. The increase in shared postural activity with increasing word similarity was present, however, only when the opposite member of the analyzed pair was present. That is, when the postural sway of 1 member of an original pair was compared with the postural sway of a member of a different pair uttering the same word sequences as his/her original partner, the influence of word similarity was not significant. Speaking alternation pattern (e.g., alternating speaking vs. speaking together) did not influence the shared postural activity of participant pairs. The results suggest that the interpersonal postural coordination observed by Shockley et al. (2003) was at least partially mediated by the coordination of participant pairs' articulatory actions. That is, in conditions in which the participant pairs in Shockley et al. (2003) verbally interacted with one another, they likely reached a common tempo of verbal interaction and used more similar utterances compared with conditions in which each member of the participant pair interacted with a different person and on a different puzzle. Testing this hypothesis comprehensively will require a replication of Shockley et al.'s (2003) experiment but with utterances recorded and analyzed with respect to the similarity of utterances and speaking rates.

Our findings are consistent with prior research suggesting that articulation influences postural sway activity (Dault et al., 2003; Yardley et al., 1999). Our results extend prior findings by demonstrating that not only does speaking influence postural sway activity but that the patterning of articulation differentially influences postural sway activity. This finding implies that investigations of the influence of any suprapostural task (e.g., a cognitive task) involving articulation on postural sway activity must control for not only speaking influences but for the spatiotemporal patterning of the utterances (e.g., number of syllables, syllable stress, speaking duration, speech onset times).

Postscript

A comparison of the findings of Experiments 1 and 2 hints at a potential limitation of CRQ analysis for the investigation of interpersonal coordination. As discussed previously in Experiment 1, we observed more than seven times the variation in %REC across participant pairs than we did across the experimental manipulation of word similarity. When participant pairs were compared with themselves across the same experimental manipulation, the influence of this variation did not mask the influence of the experimental manipulation. The implication is that individual differences in the magnitude of cross-recurrence measures of postural activity may prohibit sensitivity of these measures to between-participants manipulations.

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