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Attraction and Social Coordination: Mutual Entrainment of Vocal Activity Rhythms

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To investigate factors that affect the mutual entrainment of vocal activity rhythms, female general psychology students paired according to attitude similarity questionnaires engaged in 40-minute introductory conversations. Fourier analyses performed on speakers' on-off vocal activity demonstrated periodic oscillations in talkativeness. Although some dyads coordinated their vocal activity rhythms, speech accommodation was not predicted by attitude similarity or attraction and did not affect ratings of conversation quality. These rhythms of dialogue appear resistant to change, their behavioral momentum rooted perhaps in an underlying chronobiology.

KEY WORDS: Biological rhythms; vocal activity rhythms; social coordination; entrainment; interpersonal attraction; attitude similarity.

INTRODUCTION

A prominent example of rhythm in people's social behavior is the periodic fluctuation observed in on-off vocal activity during conversation. These rhythms involve periods of time during which a person is generally less vocally active alternating with periods when that same person is generally more active with respect to vocal activity during dyadic interaction. While conversing, people may act as timekeepers (zeitgebers) for each other's cycle rates. Optimally, interactants reach a point at which their tendencies to be talkative alternate, resulting in fewer interruptions and silent pauses. Conversational precision is thus a function of the phase relation between

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each speaker's vocal activity rhythms. The purpose of the present study is to investigate factors that affect the degree to which interacting dyads adjust to one another's vocal activity rhythms during face-to-face introductory conversations.

Vocal Activity Rhythms

Cycles in amount of talk ranging from 2 to 6 minutes in length have been observed in conversations and interviews (Kimberly, 1970; Warner, 1979; Warner, Waggener, & Kronauer, 1983; Warner, Malloy, Schneider, Knoth, & Wilder, 1987). For instance, a 6-minute cycle would include roughly one 3-minute vocally "active" phase and one 3-minute "inactive" phase. According to Warner (1979), these on-off vocal activity rhythms—called *megaturns* by Dabbs (1983)—are not explainable in terms of simple turn taking or cognitive planning cycles and do not seem related to the 90- to 100-minute fluctuations in amount of talk observed by Hayes and Cobb (1979) that appear linked to general rest/activity rhythms.

Periodic fluctuations in relative amounts of on-off vocal activity are believed to be linked to or "depend on" (Warner, 1979, p. 386) physiological timekeepers. Our biology represents a population of oscillators that drive an unknown variety of behavioral rhythms. Wever (1982) assumes the existence of "several basic oscillators that control collectively all the different rhythms." A number of behavioral rhythms have been identified, each one driven by endogenous periodicities. Wake/sleep activity is the most understood example of the link between biological and behavioral rhythms—change an organism's sleep schedule and the circadian rhythm reluctantly adjusts. Entrainment appears to be an effortful process and, in the case of jet-lag, several days may pass before synchrony is reestablished. Other rhythms are less understood.

Chapple (1970) believes that during interaction, partners coordinate their "readiness to act" and the patterns observed between interactants represent a compromise between baseline "preferences." Mutual entrainment of partners' biological rhythms thus occurs as a result of their coordinated overt activity.

Employing periodograms derived from Fourier analyses to represent cycles in on-off vocal activity, Warner and Mooney (1988) observed significant individual differences in cycle rates. As there are individual differences in biological functions, so too are there individual differences in vocal activity rhythm. It has also been demonstrated that the cyclicity of vocal activity increases over the course of a face-to-face dyadic conversation (Warner, 1992c), suggesting that as a conversation progresses, interactants search to find a rhythm that allows them to take turns holding the floor while still following their own vocal activity cycle. Warner suggested that the ease with which speakers are able to coordinate their vocal activity rhythms depends on similarities in their baseline cycling rates. That is, each person has a preferred on-off vocal activity rhythm best suited for interactions with people who have compatible rhythms. Some dyads may thus have an easier time conversing than other dyads because of a similarity in preferred cycle rates.

During interaction, people may act as timekeepers for each other's vocal activity rhythm. The idea of entrainment to time cues that are social in nature is not new; both social zeitgebers as well as light/dark cues as have been identified as potent entraining agents of people's daily activity cycle (Wever, 1979). Entrainment occurs in conversations when interactants adjust their preferred rate of cycling to match the rate exhibited by their partner—what Chapple (1982) considers a sort of musical exchange of interaction rhythms.

The degree to which conversation partners come to act as social zeitgebers on each other's cyclic vocal activity may be determined by various factors. People bring both a collection of endogenous oscillators and a set of personality characteristics to an interaction. Matarazzo, Weins, Matarazzo, and Saslow (1968) observed that the degree to which interactants coordinated their noncontent speech activity varies as a function of an individual's empathy, rapport, and social desirability. The present research was intended to investigate the effect of attitude similarity and interpersonal attraction on the mutual entrainment of vocal activity rhythms.

Interpersonal Attraction

The connection between similarity and interpersonal attraction was noted as early as 1870 by Sir Francis Galton upon observing that illustrious men marry illustrious women. Pearson and Lee (1903) also reported the selection of like by like. The relation between attitude similarity and interpersonal attraction has been extensively investigated (Newcomb, 1961; Byrne, 1961, 1971; Bochner, 1984; Duck, 1976). Through this body of research, the similarity/attraction relation has come to encompass a broad array of variables and has been studied extensively in numerous contexts. Similarity in economic position, intelligence, behavior, and various personality characteristics have been observed to affect the degree to which people are attracted to one another (Byrne, 1971).

Newcomb (1956) suggested that the amount of mutual attraction in a relationship is a function of rewards or reinforcements that are mutually provided. When two people are alike in their attitude toward a particular object they serve to reinforce each other's constructions of reality. A person who expresses similar attitudes to another becomes associated with the reinforcing value of their attitudes and can thus be considered a secondary reinforcer and, as a consequence, is more attractive to the other (Byrne & Clore, 1966, 1970). Conversely, when a relationship provides mutual "punishment" the behavior of maintaining the relationship decreases, resulting in dislike or repulsion.

Cappella and Palmer (1990) observed an effect of attitude similarity on posture and orientation in interacting dyads, as well as on the similarity of their gaze behavior. Communicative behavior accounted for a significant amount of variance in attraction and satisfaction "over and above that attributable to initial attitude similarity" (p. 177). When scores representing how similar interactants were with regard to pause and vocalization duration, eye gaze, gestures, smiles, laughter, posture, and body orientation were entered into the model predicting interpersonal attraction, the predictive strength of attitude similarity was no longer significant. This result suggests a causal model in which similarity of attitudes leads to attraction that, in turn, leads to similarity in communicative behavior.

Others have observed the influence of attitude similarity on conversational behavior. Welkowitz and Feldstein (1969) demonstrated the effect of perceived similarity on induced changes in durations of pauses, switching pauses, and vocalizations of interacting dyads. Their participants were given a series of personality questionnaires and randomly placed into two-person groups. Each dyad was told they were either similar to one another, dissimilar, or randomly placed with regard to their responses on the attitude questionnaire. The researchers observed both a degree of convergence in expressive behavior in any one dialogue, as well as increasing convergence in dyads' expressive behavior across dialogues. The observed convergence of pauses and switching pauses indicates that, overall, people tend to coordinate (with regard to pause durations and switching pause durations) with their interaction partners, but more so when they believe they are similar to the person with whom they are interacting.

The same conversations used in the Welkowitz and Feldstein (1969) study were later analyzed for convergence of speech intensity (Welkowitz, Feldstein, Finkelstein, & Aylesworth, 1972). Quantifying each participant's vocal activity in terms of loudness for each 10-second interval it was found that the degree to which people converge with regard to the intensity or loudness of their speech was a function of how similar they believed their attitudes to be.

Accommodation Theory

Speech accommodation theory (SAT) was formulated to integrate a variety of findings related to the influence people have on one another's communicative behavior. The formulation of this theory began with Giles' (1973) demonstration of interpersonal accent convergence during one-on-one interviews. Accommodation theory encompasses two general categories for speech shifts: convergent shifts, in which speech behavior of social interactants change to become more similar to one another, and divergent shifts, in which changes occur in the opposite direction.

A wide variety of social actions fall within the scope of SAT, including linguistic, prosodic, and nonverbal elements of communication. As reviewed by Giles, Coupland, and Coupland (1991), the features observed to converge during social interaction include utterance length (Matarazzo, Weins, Matarazzo, & Saslow, 1968), speech rate (Street, 1983), information density (Aronsson, Jonsson, & Linell, 1987), vocal intensity (Natale, 1975), length and frequency of pauses (Jaffe & Feldstein, 1970), response latency (Cappella & Palnap, 1981), joking (Bales, 1950), gestures (Mauer & Tindall, 1983), head nods and facial affect (Hale & Burgoon, 1984), and posture (Condon & Ogston, 1967). Speech convergence is thus a change or shift in any of an increasingly large population of expressive behavior of one person toward the behavior of another.

Accommodation theory focuses on the cognitive processes underlying behavior during social interaction. Speech shifts during interaction reflect specific purposes of the speaker. That is, shifts are strategic in nature and are seen as the product of perceptions of the situation, as well as perceptions of the consequences of the strategies taken. Convergent shifts in vocal behavior reflect a speaker's desire to increase social integration or identification with another, while divergent shifts have been explained as resulting from intentions to discontinue interaction. This perspective on expressive behavior occurring during interaction fits in well with the causal model proposed herein. In fact, Giles *et al.* (1991) acknowledged the reliance of accommodation theory on the similarity/attraction paradigm. In keeping with the notion that similarity leads to interpersonal attraction, people who desire increased connection with one another may adjust their vocal behavior in such a way as to minimize speech-related differences.

According to the similarity/attraction paradigm, those similar in attitude will likely be attracted to one another. According to accommodation theory, those who are attracted to one another will be inclined to form and maintain relations with one another. It is this inclination toward the formation and maintenance of interpersonal relations that was expected drive the convergence of vocal activity rhythms during interaction.

Assessment of Coordination: Different Approaches

Social interaction researchers have defined and analyzed coordination between partners in a number of different ways. A more extensive comparison of these approaches is provided elsewhere (Warner, 1992a). Jaffe, Beebe, Feldstein, Crown, and Jasnow (2001) performed a two-stage analysis of on-off vocal activity patterns to describe coordination in parent-infant and adult-adult vocal activity. First, following the method reported by Jaffe and Feldstein (1970), talk events were mapped into several categories (such as turns, vocalizations, switching pauses [SP], interruptive simultaneous speech, and so forth). They examined each of these types of vocal behavior as a separate variable; for instance, they looked at coordination of the durations of SPs between partners as one form of social coordination. In the second stage of analysis they calculated the mean SP duration for each speaker within each 5-second segment. Then they performed a time-series regression within each dyad to predict person A's SP from person B's SP in immediately preceding time blocks while statistically controlling for person A's own recent past SP behavior. Jaffe *et al.* (2001) showed that when coordination is assessed through this time series regression approach, moderately coordinated infant-caregiver interaction predicts the best developmental outcomes (such as secure attachment) and is sensitive to relationship variables, such as attitude similarity and warmth.

Much less research has been done on alternative indexes of coordination. The Jaffe *et al.* (2001) approach, following the recommendations on time-series regression made by Gottman (1979), provided an index of social coordination that essentially removes any cycles or rhythms from each individual's behavior before looking at linkage between partners. Warner (1992a, 1992b) has suggested that other indexes that include synchronized cycles as part of any coordination between partners may also be useful. The goal of the present study was to see whether alternative cyclic indexes of coordination are related to perceived or actual attitude similarity.

A coordination index used in the present study was derived from identification of shared cycles from the Fourier analyses of each speaker's vocal activity. The other coordination index was a simple ϕ coefficient (between the two on-off vocal activity time series). This provided a crude index of overall coordination, including the combined contributions of shared trend, cycles, and moment-to-moment adjustments to partner behavior. These two statistical indexes represent alternative ways of assessing social coordination that differ from the more widely used time-series regression approach in that they include coordinated cycles instead of statistically removing them. The question was whether these two coordination indexes were related to attitude similarity, at least as strongly as the coordination indexes used by past researchers.

The present research was intended to demonstrate convergence of vocal activity rhythms as a function of attitude similarity. Rhythm convergence may occur in two ways: entrainment in phase relation and in cycle length. First is the question of the phase relation between the rhythms of two speakers. Optimally, two people talking with one another would alternate their talkative phases. While one person experiences a period of relative talkativeness, the other would best be experiencing a period of relative nontalkativeness; they would be 180 degrees out of phase. However, it could be that when an interaction is initiated between two people, each experiences talkative or nontalkative phases concurrently. That is, the speakers could be perfectly in phase—a situation that would invite a flood of interruptions and awkward silent pauses. In all likelihood, at the onset of a conversation the phase relation between the speech rhythms of two interactants would fall somewhere between these two extremes (180 and 0 degrees out of phase).

The second form of rhythm accommodation concerns the frequency or period length of each speaker's vocal activity rhythm. It may be that the individual differences in the length of vocal activity rhythms observed by Warner *et al.* (1979) exhibit convergence as well. That is, a person with a 3-minute vocal activity rhythm may lengthen the cycle when speaking with a person with a 5-minute rhythm. Speakers motivated to increase interpersonal relations between them may alter their speech rhythms, converging to a point where they share the same cycle length and are 180 degrees out of phase. Their smooth and coordinated conversation may be perceived as more enjoyable and perhaps contribute to greater mutual attraction.

It is reasonable to presume that the attraction produced by attitude similarity provides one of the underlying motivations for the convergent or divergent shifts in vocalization rhythms occurring during social interaction. It was hypothesized that the mutual entrainment of vocal activity rhythms—in phase and frequency—would be related to actual or purported attitude similarity, that those actually similar in attitude or those *told* they were similar in attitude would be more likely to experience coordination than those who were actually or purportedly dissimilar in attitude. It was also expected that dyads exhibiting greater entrainment would, in turn, report greater liking for one another at the conclusion of their interaction.

METHOD

Participants

One hundred and seventy-four female introductory psychology students at the University of New Hampshire participated as part of a course requirement. All were told, before participation, that their attendance was required at two sessions. Participants were freshman and sophomores, typically between the ages of 18 and 25, and all spoke English as a first language.

Procedure

Data for this experiment were collected over two sessions. During the first session, groups of participants were given an attitude questionnaire derived from that used by Byrne (1971). Some antiquated items were removed and replaced with questions pertaining to such contemporary issues as abortion, interracial marriages, and recreational drug use. It was explained that participants would later be paired based on their responses to the attitude questionnaire. Participants were also asked to provide some information about when they would be available to participate in the second session.

Each participant's responses to the attitude questionnaire were compared to responses made by other participants. Attitude similarity scores were calculated for each pair of participants by comparing their responses on each attitude item. Each attitude item could be responded to in one of six ways. For instance, responses to an item on birth control could range from "I am very much in favor of most birth control techniques" to "I am very much opposed to most birth control techniques" with no mid-point. In-between answers ranged from moderately in favor, slightly in favor, slightly against, and moderately against. If two participants responded at opposite end points on an item they received a score of five for that item. If one participant responded "very much in favor" and the other responded "moderately in favor" the pair received a score of one for that item. If responses were the same for an item, the pair received a score of zero for that item. The scores for each of the 29 items were summed to form an overall attitude similarity score. The lower the score, the more similarly a pair of participants responded to the attitude items.

Participants were scheduled for the second session in pairs. Dyads fell into one of four groups: actually similar, pseudosimilar, pseudodissimilar, and actually dissimilar (Table 1). The actually similar group (n = 27) ranged in attitude similarity from 16 to 29. The actually dissimilar group (n = 21) ranged in attitude similarity from 42 to 60. The pseudosimilar and pseudodissimilar groups ranged in attitude similarity from 27 to 40.

Table I. Experimental Conditions

	Actual attitude similarity		
Told	Low	Medium	High
Told they were similar		Pseudosimilar (n = 17)	Actually similar (n = 27)
Told they were dissimilar	Actually dissimilar (n = 21)	Pseudodissimilar (n = 20)	

Pairs of participants were scheduled to arrive at separate entrances for a second session, where an experimenter greeted them and explained the basis of their pairings. Those in the similar and pseudosimilar groups were told they were paired with a person to whom they were similar in attitude based on their responses to the attitude questionnaire from the first session. Those in the dissimilar and the pseudodissimilar groups were told they were paired with another participant whose responses on the attitude questionnaire were much different than their own.

Before being brought together, participants were asked to complete Byrne's six-item (1971) Interpersonal Judgment Scale. Among the questions on this scale were two critical inquiries regarding how much they believed they would like their partner and how much they would enjoy working with their partner, with judgments made on 7-point scales. Participants were then brought into a 12-feet × 12-feet room and told to make themselves comfortable in each of two wing back chairs. The chairs were angled toward one another with their closest legs 24 inches apart. Because only unacquainted dyads were used in this study, participants were asked at this time if they knew one another. Those who had been previously acquainted were rescheduled with new partners.

Participants' on-off vocal activity was recorded using a system similar to the Automatic Vocal Transaction Analyzer (AVTA) developed by Jaffe and Feldstein (1970). Conversants each wore a Shure (SM-10) noise-canceling microphone positioned about 1 inch in front of their mouths. Once connected to this equipment, dyads were told that for the next 40 minutes they were to carry on a conversation in which they "get to know each other." The experimenter then left the room and closed the door.

Input from each speaker was fed into a separate channel of a stereo tape recorder. During playback, input from each channel was first run through a low-pass filter that removed all high-frequency components of the signal that was then passed through a threshold detecting circuit (see Jaffe & Feldstein, 1970, p. 164 for a detailed description). Thresholds for each channel could be individually adjusted using a potentiometer, allowing a human listener to adjust the input so that output corresponded with the actual vocal activity and not with any background noise such as heavy breathing or voice bleed-over (a situation in which one person's voice can be heard on the other person's channel). If voice amplitudes exceeded the set threshold, the circuit output one voltage, and if amplitudes did not exceed the threshold, the circuit output a second voltage. These binary voltage signals were fed into an analogue-to-digital converter board (Metrabyte DAS-16). A computer program then sampled the signal from each channel 400 times per second and represented dyadic vocal activity as two series of 1s and 0s. If for each ¼ second (100 samples) 51% of the voltage samples were above the set threshold, then vocal activity was coded as present ("1"). If the majority of the voltage samples were below the set threshold, vocal activity was coded as absent ("0") for that ¼ second.

After the conversation, participants were brought into separate rooms and asked to complete a second copy of Byrne's Interpersonal Judgment Scale and several 7-point Likert type questions regarding their judgment of overall conversation quality. Following the completion of these items, participants were debriefed, thanked for their participation, and dismissed.

RESULTS AND DISCUSSION

Coordination of Vocal Activity Rhythms

Time series data from the coded vocal activity were analyzed using a spectral analysis—a modified Fourier analysis. Fourier analysis represents the cyclic periodicities in time series data as a sum of sine and cosine waves. The difference between Fourier and spectral analyses is that the former assumes a deterministic process in which future events can be precisely predicted given knowledge of past events. The latter assumes a stochastic process in which future events are only partially predicted by past events.

Spectral analyses were conducted to identify cycles in each participant's vocal activity. Specifically, a periodogram analysis partitioned variance in the amount of vocal activity over time into that amount accounted for by various cycle lengths. The process operates much like a best-fitting regression line but fits data to a line that is sinusoidal.

Using the same techniques employed by Warner (1992c), vocal activity for each speaker was aggregated into 10-second time intervals. The 40-minute conversations were, as a result, broken down into 240 observations for each participant. The cycle lengths of the sinusoidal regression lines used to fit the data were a function of the number of observations. The N/2 or 120 periodic components included in the periodogram (Box & Jenkins, 1970) ranged in length as determined by 10(240/i) where i = 1,2,3,4, . . . , 120. That is, the variance in each speaker's vocal activity over the course of the 40-minute conversation was fitted to a series of sinusoidal regression lines with cycle lengths (in seconds) of 2400, 1200, 800, 600 . . . 20. If on-off vocal activity was randomly distributed across the 40-minute time series—if there was no cyclic variation in amount of talk—each periodic component would account for .83% (1/120) of the overall variance. However, if a person's vocal activity exhibited cyclic periodicities, then one or more of the periodic components would account for a greater degree of variability in that person's on-off vocal activity over the course of the conversation.

There are often two or three significant periodic components to on-off vocal activity occurring during face-to-face interaction (Warner, 1992). In the present experiment, significance levels were determined according to a set of significance tables prepared by Russell (1985). The primary periodic component in an interactant's on-off vocal activity was considered significant at the .05 level if it accounted for more than 7% of the variance in on-off vocal activity. A secondary component was considered significant if it accounted for 5% of the variance in vocal activity, and a tertiary component was significant if it explained at least 3% of the total variance.

Mutual entrainment of vocal activity required that a large proportion of the variability in the vocal activity of two interactants be explained by the same periodic component. To share the same period is to have talk rhythms occurring with the same frequency. However, evidence of shared cycles alone is not a sufficient indicator of entrainment. Periodogram analyses give no information about the phase relation of participants' vocal activity rhythms. It could be that two people whose vocal activity can both be represented by a sinusoidal wave form with a 3-minute period are cycling 180 degrees out of phase from each other, that they are taking turns holding the floor, or it could be that they are cycling perfectly in phase, that their conversation alternates between frequent interruptions and long silences. To make any conclusion regarding the entrainment of rhythms, it must be known not only that two cycles are of the same length but that their phase relation suggests coordination as well.

Vocal activity entrainment requires two rhythms that are 180 degrees out of phase, with one person's active phase coinciding with the other's inactive phase. A conversation that is in phase, in which people's active and inactive phases occur coincidentally, would be fraught with a large proportion of simultaneous speech and frequent silent periods. The contingency between the vocal activities of two interactants was expressed as a correlation coefficient. By observing the presence (1) or absence (0) of talk for two speakers during a given interval of time (in this case every ¼ second), four different event states occurred. Either both were talking (1,1), both were silent (0,0), one was talking while the other was silent (1,0), or vice versa (0,1). By recording the frequencies for each of these event states in a 2×2 matrix, a phi coefficient could be calculated. With cell a representing the frequency of simultaneous speech; b, the frequency of mutual silence; c, the frequency of one person talking while the other is silent; and d, the frequency of the other talking while the first is silent, then:

$$\text{phi} = \frac{bc - ad}{\sqrt{(a + c)(b + d)(a + b)(c + d)}}.$$

Possible phi coefficients range from −1.0 to +1.0. A conversation receiving a score of −1.0 indicated a situation in which every time one person was speaking, the other was silent and vice versa. There could be no time when both were speaking and no time when both were silent—a highly coordinated yet unlikely interaction. The degree to which two people's vocal activity rhythms were out of phase with one another was represented by the phi coefficient computed for their conversation. It was reasoned that a conversation in which both speakers were experiencing their active phases at the same time would be less precise (involving a greater proportion of simultaneous speech and mutual silence, thus receiving a less negative phi) than a conversation in which the phase of speakers' rhythms had become mutually entrained (receiving a more negative phi). Vocal activity cycles were considered out of phase (participants' bouts of relative talkativeness were alternating with one another) if conversations received a phi more negative than the overall mean value (−37.67).

On-off vocal activity entrainment was defined as a situation in which interactants exhibited cycles of similar length and in which these cycles were out of phase with one another. Conversations fell into one of three categories: (i) significantly coordinated ($n = 24$), in which the primary (Table IIa) or secondary (Table IIc) cyclic components in participants' vocal activities were the same or within one in the series of computed lengths (Table IIb) *and* the computed phi of their combined vocal activity was more negative than the overall mean phi; (ii) slightly coordinated ($n = 37$), in which interactants shared near significant periodic components (Table IIIa) or shared significant cyclic components but had phi coefficients less negative than the mean; and (iii) uncoordinated ($n = 26$), in which neither significant nor near significant periodic components in participants' vocal activities shared the same or similar frequencies (Table IIIb).

Attitude Similarity/Interpersonal Attraction

Purported Similarity

To test the effect of whether participants who were told they were similar to one another reported liking their unseen partners more than participants told they were dissimilar to their partners, each dyad's responses to the critical questions of Byrne's Interpersonal Judgment Scale were summed, producing an overall preinteraction liking score ranging from 0 to 28, with 0 indicating extreme dislike. Preconversation liking scores for all participants ranged from 14 to 27, with a standard deviation of 3.06. A one-way analysis of variance (ANOVA) was performed to test the effect of what participants were told

Table II. Proportion of Variability in Vocal Activity for Interacting Speakers Accounted for by Sinusoidal Curves of Different Period Lengths (DYADS 30, 66, and 52)

	Dyad 30 (a) Phi = −.38		Dyad 66 (b) Phi = −.42		Dyad 52 (c) Phi = −.52	
Period length	Person A	Person B	Person A	Person B	Person A	Person B
2400.0	.04	.04	.00	.10	.07***	.02
1200.0	.01	.07	.02	.01	.00	.00
800.0	.04	.02	.03	.02	.00	.00
600.0	.01	.01	.06**	.03	.04	.01
480.0	.11***	.10***	.03	.13***	.00	.02
400.0	.01	.01	.02	.01	.00	.00
342.9	.03	.03	.02	.04	.02	.02
300.0	.03	.01	.04	.02	.00	.00
266.7	.01	.01	.05	.01	.04*	.08***
240.0	.02	.04	.01	.00	.02	.01
218.2	.00	.00			.00	.00
200.0					.01	.01
184.6					.01	.00
171.4					.01	.00
160.0					.00	.01
150.0					.02	.01
141.2					.01	.01
133.3					.06**	.07**
126.3			.01	.02	.04	.04
120.0			.01	.01	.00	.00
114.3			.07***	.03		

*** indicates significance of major component (alpha = .05).
** significant as a secondary component (alpha = .05).
* significant as a tertiary component (alpha = .05).

regarding their attitude similarity (similar/dissimilar) on preinteraction attraction. The results indicated a significant relation [$F(1,84) = 70.62$, $p < .05$]. Participants who were told they were to be meeting a partner who had responded similarly on an attitude questionnaire reported greater attraction toward their unknown and unseen partner than participants who were rating an unknown and unseen partner described as attitudinally dissimilar to themselves (Table IV).

Byrne's attitude similarity/attraction paradigm (1971) predicted that people believing to be similar in attitude would report greater attraction toward one another than people believing to be dissimilar in attitude. This effect has been observed to hold in situations in which people have no more information about one another than attitude similarity/dissimilarity—little needed support for Byrne's bogus stranger paradigm.

Table III. Proportion of Variability in Vocal Activity for Interacting Speakers Accounted for by Sinusoidal Curves of Different Period Lengths (DYADS 41 and 10)

	Dyad 41 (a) Phi = −.59		Dyad 10 (b) Phi = −.31	
Period length	Person A	Person B	Person A	Person B
2400.0	.01	.04	.02	.10
1200.0	.01	.02	.00	.02
800.0	.01	.01	.05*	.01
600.0	.00	.00	.00	.01
480.0	.02	.01	.00	.00
400.0	.00	.00	.00	.01
342.9	.00	.01	.00	.01
300.0	.00	.00	.00	.00
266.7	.00	.01	.00	.01
240.0	.00	.01	.06**	.00
218.2	.06*	.06	.00	.01
200.0	.02	.02	.00	.01
184.6	.08**	.05	.01	.01
171.4	.00	.00	.03	.02
160.0	.00	.00	.07***	.01
150.0	.02	.00	.04	.01
141.2	.04	.02	.02	.01
133.3	.09***	.06	.04	.02
126.3	.01	.00	.02	.00
120.0	.01	.00	.02	.00
114.3	.03	.05	.04	.02

*** indicates significance of major component (alpha = .05).
** significant as a secondary component (alpha = .05).
* significant as a tertiary component (alpha = .05).

Actual Similarity

Cappella and Palmer (1990) observed that interactants who were similar in attitude reported greater interpersonal attraction toward one another than participants dissimilar in attitude. Treating attitude similarity as a categorical variable—dyads were either similar or not similar, actual attitude

Table IV. Preconversation and Postconversation Interpersonal Attraction Scores (with Standard Deviations) for Dyads Told They Were Similar or Dissimilar

	Attraction scores	
Told	Preconversation	Postconversation
Told similar	22.78 (2.00)	25.20 (1.93)
Told dissimilar	18.66 (2.54)	23.29 (3.67)

similarity was found to be significantly related to postinteraction attraction [$F(1,76) = 14.24$, $p < .00$].

Treating attitude similarity in the present experiment as a categorical variable, similar and dissimilar dyads' preconversation and postconversation liking scores were compared using a one-way ANOVA. As expected, there was a significant difference in preconversation attraction between similar and dissimilar dyads [$F(1,47) = 14.41$, $p < .01$]. A significant relation remained between attitude similarity and interpersonal attraction when assessed after the interaction [$F(1,47) = 9.17$, $p < .01$]. Dyads who were actually similar reported greater postconversation attraction toward one another than attitudinally dissimilar dyads. Means and standard deviations are presented in Table V.

Coordination/Postconversation Attraction

A one-way ANOVA was conducted to test the hypothesis that the coordination of on-off vocal activity rhythms (high, moderate, none) affects interpersonal attraction (postconversation liking). The results were not significant [$F(2,83) = .68$, $p > .05$]. Dyads exhibiting entrainment of on-off vocal activity rhythms reported no greater attraction toward one another than dyads that did not display entrainment. An analysis of covariance (ANCOVA) was computed between the coordination of vocal activity and change in attraction, with preconversation attraction entered as the covariate. Controlling for preconversation attraction, the effect of coordination on postconversation attraction was nonsignificant [$F(2,85) = 1.48$, $p > .05$]. It appears that interpersonal attraction, represented either as postconversation liking or as the change in liking from preconversation to postconversation, was not affected by the degree to which rhythms in interactants' vocal activities mutually entrained to one another.

A one-way ANOVA was performed to determine if a relation existed between the coordination of vocal activity rhythms and dyads' combined judgments of the quality of the interaction. The results were not significant

Table V. Preconversation and Postconversation Mean Interpersonal Attraction Scores (with Standard Deviations) for Dyads Across Experimental Condition

	Attraction scores	
Condition	Preconversation	Postconversation
Actually similar	22.41 (1.95)	25.15 (1.96)
Pseudosimilar	23.33 (2.00)	25.28 (1.93)
Pseudodissimilar	17.95 (1.99)	24.35 (3.28)
Actually dissimilar	19.64 (3.13)	22.55 (3.91)

[$F(2,83) = .17$, $p > .05$]. Vocal activity entrainment does not appear to be linearly related to judgments of attraction or conversation quality.

It has been discussed in past research (Gottman, 1979; Warner, 1992c) that for some types of dyads a high degree of coordination or predictability may be associated with negative affect. It may then be that dyads exhibiting a high degree of coordination rated the conversation as being lower in quality than those exhibiting lesser degrees of coordination. The quadratic trend in quality ratings across levels of coordination (none, slight, significant) was not significant [$F(1,83) = .001$, $p > .05$]. Whether or not participants adjusted to cycles in one another's vocal activity did not appear to influence their judgments of conversation quality.

Purported Similarity/Coordination

It was expected that interactants who *believed* they were conversing with a partner who was attitudinally similar would be more likely to adjust the phase and frequency of their speech cycles to complement their partner than interactants believing their partner to be attitudinally dissimilar. Specifically, it was expected that dyads *told* they were similar would be more likely to exhibit entrainment of on-off vocal activity rhythms than those told they were dissimilar. A two-way chi-square testing the relation between coordination (high, moderate, none) and purported attitude similarity (told similar, told dissimilar) was not significant [$\chi^2(2) = 1.09$, $p > .05$].

To better test the relation between purported attitude similarity and coordination, a second chi-square was performed involving only those in the pseudosimilar condition (those moderate in attitude similarity who were told they were similar) and those in the pseudodissimilar condition (those moderate in attitude similarity who were told they were dissimilar). This relation was also not significant [$\chi^2(2) = 2.38$, $p > .05$].

It was previously suggested that the entrainment of speech rhythms could be examined in accommodation theory terms as adjustments made in communicative behavior toward some end, in this case increased liking. Giles *et al.* (1991) has acknowledged the reliance of accommodation theory on the similarity/attraction paradigm. Whereas the similarity/attraction paradigm insists that people similar in attitude will attract one another, accommodation theory asserts that those attracted to one another will act to maintain their relationship. That is, inclinations to increase and decrease social integration or identification with another should result in convergent and divergent shifts in behavior, respectively. Given this, the entrainment of vocal activity rhythms was expected to strengthen the social bond between speakers, to increase interpersonal attraction and overall perceptions of conversation quality. It had no such effect. Attitude similarity (either purported or actual) did not lead to the entrainment of participants' vocal activity rhythms, and those who did exhibit mutual entrainment were no more likely to rate the conversation as being high in overall quality.

Some dyads appear to coordinate their speech rhythms and some do not. Where we did observe entrainment it did not occur at the very start of conversations; rather it occurred gradually. On-off vocal activity rhythms seem slow to change, perhaps a product of an effortful process not unlike those underlying the phenomenon of jetlag. The apparent resistance of this social behavior to change might serve as an example of the notion of behavioral momentum as discussed by Nevin and Grace (2000), in which the persistence of a response is an analogue to momentum as referred to in Newtonian physics. The greater the mass of an object, the more resistant it is to changes in the direction of its movement, the greater is its momentum. Thus a behavior gains mass through various means (motivation, reinforcement history, habit, and so on), gains momentum, and can resist change. Vocal activity rhythms have momentum in that they are either slow to coordinate during face-to-face dyadic interaction or resist coordination altogether.

As with our wake/sleep cycle, an underlying biological clock might contribute to the momentum of the vocalization rhythms we have observed. It takes several days to overcome jetlag, to adjust wake/sleep activity in keeping with new environmental schedules, and wait for biological cycles to entrain. Endogenous timekeepers may thus contribute to the mass of the behavioral rhythm. Resistance to change presumably allows for rhythm stability, an adaptive characteristic of cycles associated with various biological functions (a notion discussed by Chapple, 1970). Cyclic periodicities have been observed in behavior ranging from biochemical processes (cellular respiration, neurotransmission) to overt activity (hibernation). Interestingly, these chronobiological rhythms often synchronize with social zeitgebers, perhaps regulating some unforeseen aspects of interpersonal interaction. Each of us represents a population of oscillators, as suggested by Chapple, interacting by, in some circumstances, synchronizing with other people presenting their own populations of oscillators.

Of present interest were the cyclic components of on-off vocal activity and the entrainment of these social rhythms to social zeitgebers. We intended not only to extend the population of observed instances of behavioral entrainment to social time cues, but to begin to understand some of the determinants and outcomes of this entrainment as well. Vocal activity rhythms were expected to synchronize with the on-off vocal activity of a conversation partner. Marginal to significant entrainment was, in fact, observed in over a third of the recorded conversations—an observation corroborating past work (Warner, 1979, 1992c; Warner *et al.*, 1983). However, while we set out to identify factors that predict the entrainment of vocal activity rhythms, none of the variables assessed in the present experiment were associated with the coordination of these rhythms. So while a good number of conversations (at least those occurring in our laboratory conditions) involve the cyclic coordination of bouts of talkativeness and relative nontalkativeness, without further research we do not yet know what antecedent conditions predict it or what role it might serve in how people relate to one another.

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