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# Are We on the Same Wavelength? Interpersonal Complementarity as Shared Cyclical Patterns During Interactions

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The present study addressed hypotheses about cyclical entrainment between interacting dyad members in their moment-to-moment levels of dominance and affiliation. Using a computer joystick technique, observers recorded the continuous stream of behavior for each partner in 50 mixed-sex dyads, and the data for each dyad were submitted to time-series analyses, including cross-spectral analysis. Although potentially interesting individual differences emerged, in most dyads, partners shared behavior cycles of roughly the same frequency with strongly correlated variations in amplitude (coherence). Consistent with interpersonal theory, partners' affiliation behaviors were very strongly in phase, whereas their dominance behaviors were equally strongly out of phase. In addition, these cyclical forms of interpersonal complementarity were distinguishable from other forms, such as mutual adjustment in overall levels.

*Keywords:* dyadic processes, interpersonal complementarity, interpersonal theory, mutual adaptation, time-series analysis

As two people interact, they engage in an ongoing give-and-take process that is based on mutual responsiveness to each other's behavior. When this process of mutual adjustment goes well, people may remark that they are "in synch" or "on the same wavelength." One goal of the present article is to show that there is an important literal truth behind these colloquialisms. That is, as people converse and work together, major interpersonal issues—namely, agency and communion—come to have strongly entrained cyclical patterns, making partners' behaviors as interlocked or interdependent, as if they were dancing together.

A second goal of the present article is to bring two literatures that have remained quite separate into productive and, we believe, highly promising contact. These are the literature on mutual adaptation in social interaction (e.g., Burgoon, Stern, & Dillman, 1995; Cappella, 1996; Warner, 1988) and the literature on interpersonal theory (e.g., Carson, 1969; Kiesler, 1983, 1996). These approaches have much to offer each other; however, a major impediment to cross-talk between them is the tendency to use key terminology, for example the terms "reciprocity" and "complementarity," to mean quite different things. Fortunately, these terminological incompatibilities are readily resolved, as demonstrated in the following brief review of each of these literatures.

## Mutual Adaptation in Social Interaction

Cappella (1996) characterized peoples' adaptation of their interaction patterns to each other as "the defining characteristic of interpersonal communication" (p. 354), and he drew attention to how these patterns "mold, maintain, and destroy" relationships (p. 355). Studies have examined processes of mutual adaptation in adult interactions with regard to a wide variety of specific behaviors, including, for example, speech rate (Street, 1984), speech accents (Giles & Powesland, 1975), postural and gestural behaviors (Maurer & Tindall, 1983), head nods and facial affect (Hale & Burgoon, 1984), gaze direction (Noller, 1984), and stares (Greenbaum & Rosenfeld, 1978). These behaviors indicate much interest in multiple channels and alternative mechanisms underlying interactional adaptation.

Irrespective of the specific behaviors involved, the literature has identified major possible patterns by which mutual adaptation may be evident. Cappella (1996) drew a strong distinction between two major components at play during social interactions. What he termed "mutual influence" refers to correlated adjustments of overall level between partners—for example, both partners linearly increasing in affiliative behavior over the course of an interaction. In contrast, what he termed "mutual adaptation" refers to "the

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dynamic process by which partners respond to changes in one another's behavior during interaction" (p. 354)—for example, the tendency for particular changes in one person's behavior to be linked with changes in the other person's behavior, holding constant any overall trends. Cappella (p. 359) argued that both of these components are "necessary for studying interpersonal interaction," but it is essential not to confound them.

A pattern of mutual adaptation that has attracted particular attention is the meshing or entrainment of recurrent cycles of behavior between partners (Bernieri & Rosenthal, 1991; Burgoon, Buller, & Woodall, 1989; Condon & Ogston, 1971; Chapple, 1970, 1982; Davis, 1982; Hatfield, Cacioppo, & Rapson, 1994; Warner, 1988). Although a number of different terms have been used to describe such coordinated rhythms in social interaction, Burgoon et al. (1995) proposed the adoption of the term "interactional synchrony," defined as "similarity in rhythmic qualities and enmeshing or coordination of the behavioral patterns of both parties" (p. 128). They argued that such synchrony qualifies as mutual adaptation "because both participants are pacing and meshing their interaction according to the same rhythm" (p. 124). Entrained rhythms constitute a form of dynamic equilibrium in which partners vary their behaviors over time while keeping this variation within desired limits, a process that Field (1985, p. 450) described as "psychobiological attunement."

In recognition of the potential importance of interactional synchrony, Warner (1998) expanded Cappella's (1996) distinction between mutual trends and dynamic relations into a threefold distinction. Warner proposed that variations across time in a person's interaction behavior can be decomposed into three basic components: trends (especially the slope, or overall change), cycles (rhythmic, more or less regularly repeating variations), and residual fluctuations (not predictable by trends or cycles in that person's behavior). Thus, for partners in an interaction, their patterns over time may be interrelated in three distinguishable ways: the relation between overall trends, the relation between cycles, and the relation between residual fluctuations (those not due to trends or cycles). This important threefold distinction forms the basis for the approach in the present study.

## Interpersonal Theory

Interpersonal theory tends to focus on much more molar variables than much of the research we just reviewed. Indeed, the foundational principle of interpersonal theory is that a great deal of the most important variation in interpersonal behavior occurs along just two major orthogonal dimensions: dominance versus submissiveness and affiliation versus hostility (Carson, 1969; Kiesler, 1983, 1996). A considerable body of work links these two dimensions to the two overarching motivational preoccupations people have in dealing with others—namely, the need for agency and the need for communion (Bakan, 1966; Wiggins, 2003).

An advantage of viewing interaction behaviors through these two rather general dimensions is that, in important ways, exchanges between partners are likely to be based on broad functional equivalents that have comparable relational meaning, rather than identical specific behaviors. Hence, knowing the major functional classes of interaction behavior, within which many different behaviors (including different channels) may be substitutable for one another, may be essential for correctly understanding such interchanges.

Another advantage of these interpersonal dimensions is that they form a two dimensional space in which a person's moment-to-moment interpersonal behavior during an interaction may be represented as a reasonably continuous trajectory over time. This property serves as the basis for the measurement technology advanced in the present article, in which a computer joystick is used to provide a continuous representation of a target person's moment-to-moment variation in behavior during an interaction.

Another important principle of interpersonal theory is the concept of *complementarity*. This term is sometimes used to characterize the relatively static interpersonal styles of the two people in a dyad—that is, the match or mismatch of the two people's interpersonal traits, irrespective of any changes in their behaviors that might occur during interaction between them (e.g., Estroff & Nowicki, 1992; Gurtman, 2001 [Study 1]; O'Connor & Dyce, 1997; Smith & Ruiz, 2007; Tracey, Ryan, & Jaschik-Herman, 2001; Yaughn & Nowicki, 1999). However, the term complementarity is also used to describe the dynamic interplay of behavior between two people during interaction—that is, people's mutual adjustments to each other, and therefore the changes in behavior, that occur during the course of interaction.

Indeed, a major aspect of interpersonal theory is its predictions about the expected directions of such mutual adjustment (Carson, 1969; Kiesler, 1983, 1996). With regard to dominance, the expected relation is one of oppositeness, in which greater dominance in one partner corresponds with greater submissiveness in the other, and vice versa. In interpersonal theory, this tendency toward oppositeness on the dominance dimension is called *reciprocity*. With regard to affiliation, the expected relation is one of sameness, in which greater friendliness in one partner corresponds with greater friendliness in the other, and vice versa. In interpersonal theory, this tendency toward sameness on the affiliation dimension is called *correspondence*.

It is important to point out that the meanings of these three key terms in interpersonal theory—complementarity, reciprocity, and correspondence—are inconsistent with the terminology used in the literature on mutual adaptation in social interaction. In the mutual-adaptation literature, *complementarity* refers only to the exhibition of dissimilar behavior; it does not serve as a more general term also taking in behavioral similarity, as in interpersonal theory. Even more confusingly, in the mutual-adaptation literature, *reciprocity* refers to "adaptation in which one responds, in similar direction, to a partner's behaviors with behaviors of comparable functional value" (Burgoon et al., 1995, p. 129). Thus, what interpersonal theorists call *correspondence* is termed *reciprocity* in the mutual-adaptation literature. The mutual-adaptation literature uses a different term for what interpersonal theorists call *reciprocity*: It is called *compensation*, defined as "adaptation in which one responds with behaviors of comparable functional value but in the opposite direction" (Burgoon et al., 1995, p. 129). Despite this terminological confusion, the parallel underlying concepts are clearly the same.

In previous research guided by interpersonal theory, mutual adaptation during interpersonal interactions has been investigated either very macroscopically, by assessing the overall adjustments of the levels of behavior over the entire course of an interaction (Locke & Sadler, 2007; Markey, Funder, & Ozer, 2003; Markey,

& Kurtz, 2006; Moskowitz, Ringo Ho, & Turcotte-Tremblay, 2006; Sadler & Woody, 2003; Tracey, 2005), or very microscopically, by breaking an interaction into many separate acts and assessing the numerous antecedent–consequent relations that occur throughout the interaction (Gurtman, 2001 [Study 2]; Tracey, 1994, 2004; Tracey, Sherry, & Albright, 1999). However, interpersonal theory is not particularly specific about the time scale (or level of detail) at which such adjustments occur, and there is considerable consensus that these two levels (overall trends and act-by-act relations) do not exhaust the phenomenon of interpersonal complementarity.

For example, with regard to the act-by-act level, Pincus (1994) has noted that complementarity "should not be conceived of as some sort of stimulus-response process based solely on overt behavioral actions and reactions" (p. 121). One important reason is that partners predict and anticipate each others' behaviors, so it may not be individual acts that are driving each other. Kiesler (1996) lamented that "we have little systematic knowledge regarding the lawful redundancies that characterize the natural sequence of distinct interpersonal transactions" and drew attention to "the necessity of charting empirically the distinctive course . . . by revealing patterned redundancies occurring over time" (p. 91). Similarly, Peterson (1982) argued that "to describe a relationship, one must identify the recurrent patterns of interaction that take place between the people involved" (p. 150).

## The Present Study

We propose that the answer to Kiesler's (1996) call for "patterned redundancies" in interpersonal theory corresponds to the well-established phenomenon of interactional synchrony in the mutual-adaptation literature. The study of such across-partner entrainment also fulfills Kiesler's (1996) call to measure the "properties of a transacting dyad, in contrast to assessing individual behavior within a dyad" (p. 99).

It is not necessary to view the relevant cycles of behavior in each partner as being perfectly regular and having one exact frequency, like a pendulum. Instead, they are better conceptualized as nondeterministic, such that they repeat themselves only more or less regularly, with a peak across a band of frequencies (Gottman, 1981). Furthermore, these rhythms in the partners' respective streams of behavior may be more or less synchronized or entrained to each other. In essence, we hypothesize that such entrainment in an interacting dyad will constitute another important form of interpersonal complementarity.

According to the hypotheses of complementarity, the entrainment of dominance-related behaviors across partners should tend to be inverse: The peaks in any cycles of one person should correspond with the troughs in the corresponding cycles of the other person, and vice versa. This hypothesis is similar to Lederer and Jackson's (1968) concept of reciprocity of control, wherein control flows easily from one partner to the other and back again as the unfolding situation requires. In contrast, the entrainment of affiliation-related behaviors across partners should tend to be direct: The peaks in the cycles of one person should correspond with the peaks of the other person, and the troughs should correspond with the troughs.

In summary, the processes regulating agency and communion may be cyclical, such that the dyadic behavioral adjustment is a set of recurring patterns. In addition, consistent with the mutual-adaptation literature (e.g., Warner, 1998), we wish to show that these interrelated cycles can be empirically distinguished from (a) slope-like, mutual adjustments of each person's overall level, and (b) nontrend-related, noncyclical, residual ("random") effects of partners on each other.

## Method

### *Participants and Procedure for Obtaining Videotaped Interactions*

The videotaped interactions used in this study were of 50 previously unacquainted male–female dyads working together to complete a personality assessment task. Participants were undergraduate students recruited from classes in introductory psychology. Based on the paradigm in Sadler and Woody (2003), participants were told that this study was about how people work together to solve problems. They received some basic information about the Thematic Apperception Test (TAT; Murray, 1943) and how it is used. They were then given five TAT cards and stories for these cards, which were previously collected from a third person (a 28-year-old woman). Participants were instructed to take 20 min to discuss this material and reach agreement about the personality of the person who provided the stories. In addition to being engaging for undergraduates, this task is very open-ended, so the dyads need to work out, in a spontaneous and unscripted way, how to approach it.

The bivariate time series used in the present study were generated for the last 10 min of the 20-min interaction period. This segment was chosen for two reasons: (a) For the first few minutes, participants often spent some time silently reading the materials provided and thus were not yet interacting with each other consistently, and (b) we wanted to give the dyad members enough time to settle into the task and establish their style of interaction. In addition, 10 min seemed to be a sufficient length of time to pick up any stable patterns of interaction.

### *Materials and Measures for Observational Ratings*

*Computer joystick apparatus.* A computer joystick apparatus was designed so that observers could provide moment-to-moment assessments of a target's behavior throughout the course of an interaction. The apparatus consisted of a Microsoft Sidewinder Force Feedback 2 joystick connected to a Pentium IV personal computer running the Windows XP operating system. An executable joystick-monitoring software program that was designed in our lab displayed a Cartesian plane that was approximately 6.8 cm wide × 6.6 cm tall on the computer screen.[1] To depict the axes of interpersonal theory, we labeled the right and left endpoints on the *x*-axis as *friendly* and *unfriendly*, respectively, and the top and bottom endpoints on the *y*-axis as *dominant* and *submissive*, respectively. The scale on both axes ranged from −1,000 to 1,000, such that 1,000 on the *x*-axis indicated extreme friendliness, and 1,000 on the *y*-axis indicated extreme dominance.

[1] The joystick-monitoring software program is available from Pamela Sadler upon request. A number of parameters can be easily modified, including the labels for the axes and the sampling rate.

A dot that moved in accordance with the current position of the joystick was shown in the Cartesian plane. Movement along the horizontal axis signified shifts in friendliness-related behaviors, whereas movement along the vertical axis signified shifts in dominance-related behaviors. To allow for continuous "real-time" measurement of social behaviors, the software program was set to write the joystick position within the Cartesian plane (i.e., the *x* and *y* coordinates) to a text file twice per second (every 0.5 s).

The videotape of the interaction being rated appeared on the same computer screen as the Cartesian plane, so that trained observers could watch the interaction and see their current joystick position simultaneously. The videotaped interaction appeared within a window that was approximately 23 cm wide × 16 cm tall, and the Cartesian plane was located just outside the lower right side of the video display. In addition to the visual feedback of the current dot location on the Cartesian plane, the force-feedback feature of the joystick provided tactile information to the observer about the joystick's current position within the two-dimensional space. Specifically, the further the joystick was pushed in any direction from the center, the greater the force that was applied against the hand in the opposite direction.

*Social Behavior Inventory (SBI).* As a benchmark for comparison of some aspects of the joystick-derived data, we included a well-validated, more traditional observational rating scale, the SBI (Moskowitz, 1994). On this scale, respondents indicate how often the target person engaged in 44 different behaviors during the observed interaction, with response options ranging from 1 (*almost never*) to 6 (*almost always*). Two of the original 46 items on this scale were not included because they were expected to have very low base rates during this particular situation (i.e., "This person asked for a volunteer" and "This person gave incorrect information"). The items yield a friendliness dimension score and a dominance dimension score. These scores have strong psychometric properties and have been shown to track important interpersonal phenomena (e.g., Sadler & Woody, 2003).

### Training Procedure for Observers

Four independent observers (two men and two women) used the joystick apparatus to rate the stream of behaviors for all interactants. Three observers were graduate students and one was a senior undergraduate student.

Before rating the data for this study, each observer underwent approximately 8 hr of individual training with the joystick apparatus. To begin, observers were familiarized with how the computer joystick apparatus works and practiced using the joystick to rate both interpersonal dimensions simultaneously. To evaluate their understanding, they were instructed to move the joystick to the correct location in the Cartesian plane in response to each of 16 interpersonal adjectives. Figure 1 shows these adjectives and their correct placement. According to interpersonal theory, this circular continuum of interpersonal descriptors constitutes an arrangement that is very intuitively accessible to raters (Wiggins, 1982). Any incorrect responses were discussed, and the process was repeated until all the words were correctly located within the Cartesian plane.

Next, each observer used the joystick apparatus to code six video segments showing various dyadic interactions (of 3–15 min in duration). Observers watched each video twice, each time coding a different interactant, for a total of 12 joystick assessments. The trainer monitored each observer's performance periodically and discussed any problems or questions as they arose. Following each joystick assessment, the trainer checked that observers were able to justify their joystick ratings by referring to changes in relevant observable behaviors of the target person. Thus, we emphasized that the joystick ratings were to be behaviorally anchored focusing on the target person, rather than simply reflecting observers' general sense of how the interaction was progressing or any assumptions based on the partner's behavior. In addition, in cases where an important behavior change in the target person was not captured in the observer's joystick ratings, this omission was brought to the attention of the rater and discussed. Thus, we also emphasized the need for observers' continuous attention and sensitivity to changes in the target person's ongoing behaviors. In contrast, the training de-emphasized any assumptions about the possible interrelation of behaviors between the individuals in an interaction.

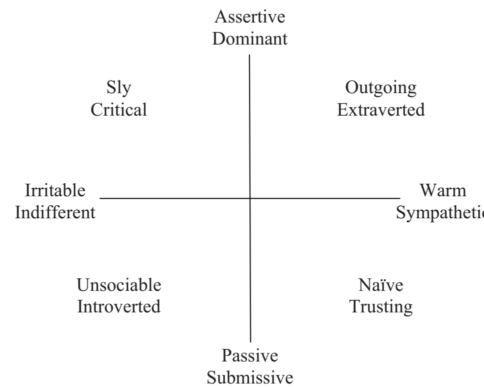


*Figure 1.* Interpersonal adjectives used in the training procedure and their correct placement in the interpersonal circumplex.

Another important issue that arose in training is how to handle any short lulls in the conversation that may occur during the interaction. Observers were instructed to keep the joystick in approximately the same position during such lulls, unless the lull was unexpected in some interpersonally relevant way, or became elongated such that, for example, the target person appeared to be waiting for the other person to take charge (which could denote submissiveness) or appeared to be somewhat unwilling to engage with the other person (which could denote hostility). In such circumstances, a gradual shift toward other positions on the Cartesian plane might be warranted.[2]

Because of the challenge of paying close and continuous attention to the behavior of the target person when making joystick ratings, each training session was limited to no more than 2 hr. The introduction to the joystick and the foregoing assessments and discussions took place over three separate sessions, for a total of

[2] A challenge we have sometimes encountered in training is the occasional tendency for a rater to move the joystick much too conservatively, such that the resulting time series is almost monotonic. A rough benchmark for a reasonably well-trained rater is that the correlation of his or her time series with that of another well-trained rater should consistently be above .40, as computed for each of the target individuals in a few dyads.

approximately 6 hr. In the fourth and final training session, a number of important issues were covered to prepare observers for rating this particular set of videos. For example, observers were given the five TAT cards and the stories for each of them, so they would be familiar with what people in the videos would be discussing.

### *Procedure for Obtaining Observer Ratings*

To assess the interpersonal behavior of a participant in an interaction, the observer started the video clip 10 s before the beginning of the 10-min segment to be rated and then pressed the start button for the joystick exactly as the segment began. By moving the joystick appropriately for the next 10 min, the observer provided a continuous rating of the target person in the space defined by the two interpersonal axes.

Every observer assessed the moment-to-moment interpersonal behavior of each interactant from each dyad. Thus, every observer rated a total of 100 interactants. To avoid assessing the two partners from the same dyad consecutively, the observer rated the behavior of only one interactant from each dyad before moving on to another video clip. In addition, to avoid assessing either men or women sequentially, the observer rated a different gendered interactant from one video clip to the next. Once the observer had rated one interactant from all dyads, he or she went through all the video clips a second time, this time rating the remaining interactants. The order in which participants were rated was varied across the observers.

Completely separate from the joystick ratings, two other raters independently watched each video and completed the SBI for each interactant. The rater watched the 20-min interaction once and then rated both partners. To obtain aggregate scores for the affiliation and dominance dimensions, we averaged the respective scores across the two raters.

### *Handling of the Time-Series Data*

Preliminary screening of the time-series data indicated that, in some cases, at the beginning of the series, the observer was still in the process of moving the joystick quickly from its resting position (the origin) to the position denoting the first genuine rating of the target person. Thus, to avoid the possibility of "boxcar" artifacts (Warner, 1998), we omitted the first 5 s from every time series.

The resulting time series, then, each had a duration of 595 s (600 s − 5 s), or 1,190 data points (595 s × 2 samples per second). This length and the sampling frequency of 0.5 s determine the set of orthogonal frequencies into which the spectral analyses decompose the series. There are 595 such frequencies. Of these, most are likely too high to be of much importance for capturing phenomena in the present study (80% of the orthogonal frequencies have periods shorter than 5 s). Thus, the lowest frequencies are by far the most relevant. Expressed as the length of a cycle, the 10 lowest frequencies are 595.0 s (9.9 min), 297.5 s (5.0 min), 198.3 s (3.3 min), 148.8 s (2.5 min), 119.0 s (2.0 min), 99.2 s (1.6 min), 85.0 s (1.4 min), 74.4 s (1.2 min), 66.1 s (1.1 min), and 59.5 s (1.0 min); the *x*-axis of Figure 4 provides the continuation of this series. All spectral and cross-spectral analyses were smoothed using a Tukey-Hamming window with a span of 5. This span was chosen because windows of greater span tended to obscure the distinction between low-frequency peaks.

For the time-series analyses, the moment-to-moment ratings of the four observers were aggregated by computing the average at each time point, thus yielding a new time series in which the value at each time point is the mean of the observers' ratings. By averaging across multiple observers, the idiosyncrasies of the individual raters tend to cancel out, leaving a truer picture of the underlying interaction. The resulting data from each dyad yielded two key bivariate time series: one for the partners' levels of affiliation over time and another for the partners' levels of dominance over time. Our general approach was to submit each dyad to time-series analyses to derive indices describing that series and then to summarize these results across the entire sample of 50 dyads by computing relevant summary statistics for the indices.

## Results

### *Means and Psychometrics for the Time Series of Individuals*

We first examined whether the joystick method would reliably and validly capture the same information about overall levels of interpersonal behavior as more traditional interpersonal measures, such as the SBI (Moskowitz, 1994). For each observer's view of each individual participant, we calculated the mean of the time series for affiliation and the mean of the time series for dominance. The aggregate of these means across the four observers yielded the psychometric results shown in Table 1. For both affiliation and dominance, the joystick-derived indices of overall level were highly reliable (Cronbach's alpha computed across the four observers). The indices also showed very strong convergent and discriminant validity with the SBI. The strong convergent correlations are particularly impressive given that the SBI scores were provided by observers who were completely independent from those providing the joystick data.

In addition to capturing such information about overall levels, the special advantage of the joystick method is its potential for capturing more fine-grained information about the nature of fluctuations within a time series. For these purposes, it is the psychometric integrity of the moment-to-moment variations in each time series that is crucial (rather than their overall means). This is an issue that does not seem to be addressed much in the psychological literature on time-series analysis (e.g., Gottman, 1981; Warner, 1998), possibly because the problem of the relevant variance components is complex (and may differ depending on the model

Table 1
*Reliability and Validity of Means for Individual Time Series*

| | Affiliation | | Dominance | |
|---|---|---|---|---|
| | Female | Male | Female | Male |
| Inter-rater reliability | .80 | .82 | .88 | .87 |
| Correlation with SBI affiliation | .66* | .64* | −.03 | −.15 |
| Correlation with SBI dominance | .11 | −.15 | .78* | .82* |

*Note*. SBI = Social Behavior Inventory (Moskowitz, 1994).
* $p < .001$.

being considered). For benchmarking purposes, we adopted the following approach. For each time series, we calculated the proportion of the shared variance to the total variance, where the shared variance (analogous to "true score variance" in classical test theory) was estimated as the mean of the cross-covariances computed across every pair of observers, and the total variance was the variance of scores averaged across the four observers. The resulting values were generally fairly good and yielded the following means across the 50 women and the 50 men: .65 for women's affiliation, .60 for men's affiliation, .67 for women's dominance, and .68 for men's dominance. Although these values are not strictly comparable to classical reliabilities (because the relevant error includes nonrandom components), they support the idea that it is advantageous to use multiple observers with the joystick technique.

### *Overall Tests of Moment-to-Moment Complementarity: Cross Correlations for Dyads*

To evaluate the hypotheses of interpersonal complementarity, we examined the bivariate time series for each dyad. Figure 2 shows two examples from the present dataset of the bivariate time series relating partners' moment-to-moment levels of affiliation across the 10-min interaction. In Figure 2A, the dyad members' fluctuations appear to track each other quite closely, suggesting a strong positive relation in moment-to-moment levels of affiliation. In contrast, in Figure 2B, the small-scale fluctuations in the partners' levels of affiliation do not appear to correspond closely; however, overall, both time series tend to increase together, which is especially notable around the middle of the interaction.

Figure 3 shows two examples of the bivariate times series relating partners' levels of dominance. The dyad in Figure 3A shows a consistently strong inverse relation in the moment-to-moment levels of dominance. In contrast, the dyad in Figure 3B shows a much less consistent relation: The partners sometimes appear to move in opposition but, at other times, appear to move in parallel.

An intuitively appealing index of the overall degree of interrelatedness in such bivariate time series is simply the moment-to-moment cross correlation between the partners. Warner (1998) described this as a useful estimate of "overall coordination—combining the contributions of any trends, cycles, and residuals" (p. 135). Although we later distinguish these three types of contribution, it is valuable to begin with an index that combines their effects.

Correlating the partners' moment-to-moment levels of affiliation for each of the 50 dyads yielded values that ranged from −.11 to .84, with a mean of .51 and a standard deviation of .21. Consistent with the hypothesis of sameness in affiliation ("correspondence" in interpersonal theory), the obtained values were positive for 48 of the dyads, and the mean of the correlations was significantly greater than zero, $t(49) = 15.18$, $p < .001$. In contrast, correlating partners' moment-to-moment levels of dominance yielded values ranging from −.83 to .09, with a mean of −.43 and a standard deviation of .21. Consistent with the hypothesis of oppositeness in dominance ("reciprocity" in interpersonal theory), the obtained values were negative for 48 of the dyads, and the mean of the correlations was significantly less than zero, $t(49) = -14.16$, $p < .001$.[3]

Although these results appear to show strong support for moment-to-moment interpersonal complementarity, there are three potentially important reservations about the cross correlation that must be addressed. First, in some instances, cross correlations can be spurious, reflecting only the autocorrelations within each time series, rather than any real connection between the series. Some methodologists have identified this as a major problem in the interpretation of cross correlations (e.g., Gottman, 1981; Jenkins & Watts, 1968; Sackett, 1980).

In the present study, we can readily evaluate this spuriousness hypothesis by examining the cross correlations between the time series of pseudo-dyads—that is, pairs of participants who did not actually interact together (cf. Gurtman, 2001). The paired time series of such pseudo-dyads retain the same autocorrelations within each series as the real dyads but remove any real connection between the two people. Across the 2,450 possible female–male pseudo-dyads, all pairs of the affiliation time series yielded a mean cross correlation of .03, with a standard deviation of .25, and all pairs of the dominance time series yielded a mean cross correlation of .01, with a standard deviation of .19. In both of these approximately normal distributions of pseudo-dyad cross correlations, positive and negative values were equally likely, unlike the results for the real dyads. Moreover, the vast majority of the cross correlations for the real dyads fall at least two standard deviations away from the means for the pseudo-dyads. Hence, we can soundly reject the hypothesis that the results for the real dyads are spurious reflections of the autocorrelations within individual time series.

Second, it is possible that the cross correlations might reflect only shared overall change, or linear trend, rather than the smaller scale phenomena in the bivariate time series (Cappella, 1996). We can evaluate this hypothesis by removing the linear trend from each partner's time series (i.e., calculating residuals from a linear regression with time as the predictor) and then computing the cross correlation between the residuals from the respective linear regressions. In the present data, this detrending has relatively little effect on the cross correlation for most dyads. For example, before detrending, the cross correlation for Figure 2A is .77; after detrending, it remains .77. Similarly, the cross correlations of −.67 and −.21 for Figures 3A and 3B, respectively, are unaffected by detrending. However, in some cases, removing the linear trends makes a substantial difference: Before detrending, the cross correlation for Figure 2B is .65; detrending reduces it to .29.

Nonetheless, for the dataset considered as a whole, removal of the linear trends had almost no overall effect on the mean cross correlations, the detrended values of which were .50 for affiliation and −.43 for dominance (both *SD*s = . 21). Hence, we can reject the hypothesis that the cross correlations just reflect shared linear trend. (In the next section, we provide a specific analysis of shared trend.)

Third, the moment-to-moment cross correlations were computed with no time lag, and hence, it is possible that these same-time correlations would fail to capture aspects of interrelatedness that may be occurring with time lags. For example, rather than being relatively simultaneous, the woman's behavior may lead or follow the man's behavior by some amount of time.

[3] Although it is well known that distributions of correlations can be skewed, the distributions of all the sets of cross correlations reported in this article were reasonably close to normal, with skewness and kurtosis values falling well within cutoffs suggested by Finch and West (1997).

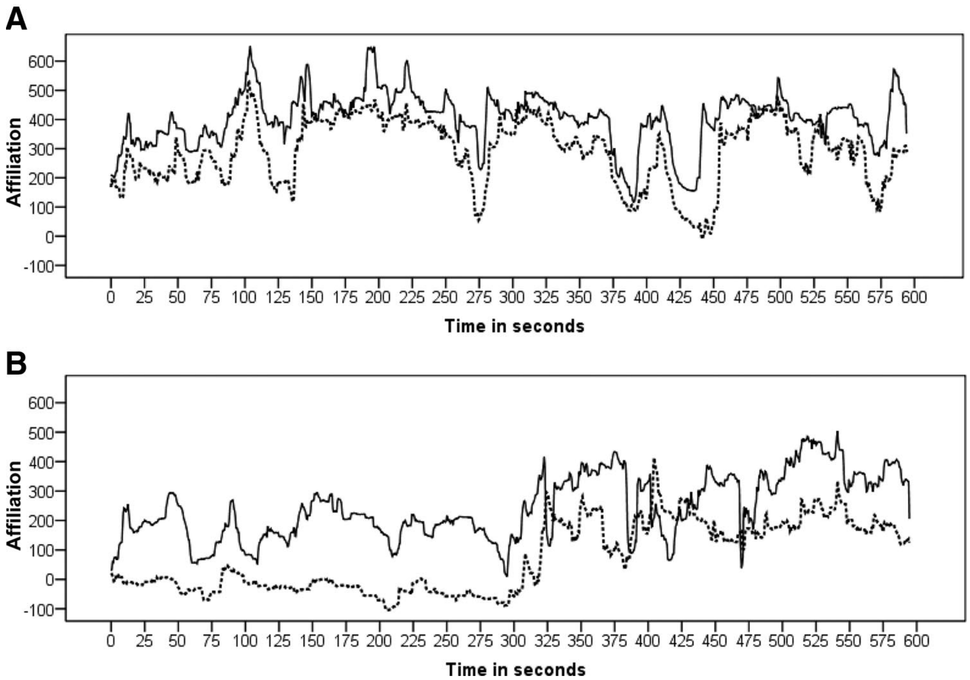


*Figure 2.* Two examples of bivariate time series of woman's affiliation (solid) with man's affiliation (dotted).

To evaluate this possibility, for affiliation and for dominance in each dyad, we computed the cross-correlation function (CCF), which portrays the correlation as a function of a wide range of time lags (−250 s through 250 s). Of the 50 resulting CCFs for affiliation, 41 (82%) showed a very clear high point (maximum positive correlation) at the lag of zero, with the correlation typically falling off fairly sharply at increasing lags in each direction. A further four CCFs (8%) showed a modest peak at lag 0, with a somewhat higher peak elsewhere; however, the location of this peak was not consistent across these dyads. Of the 50 CCFs for

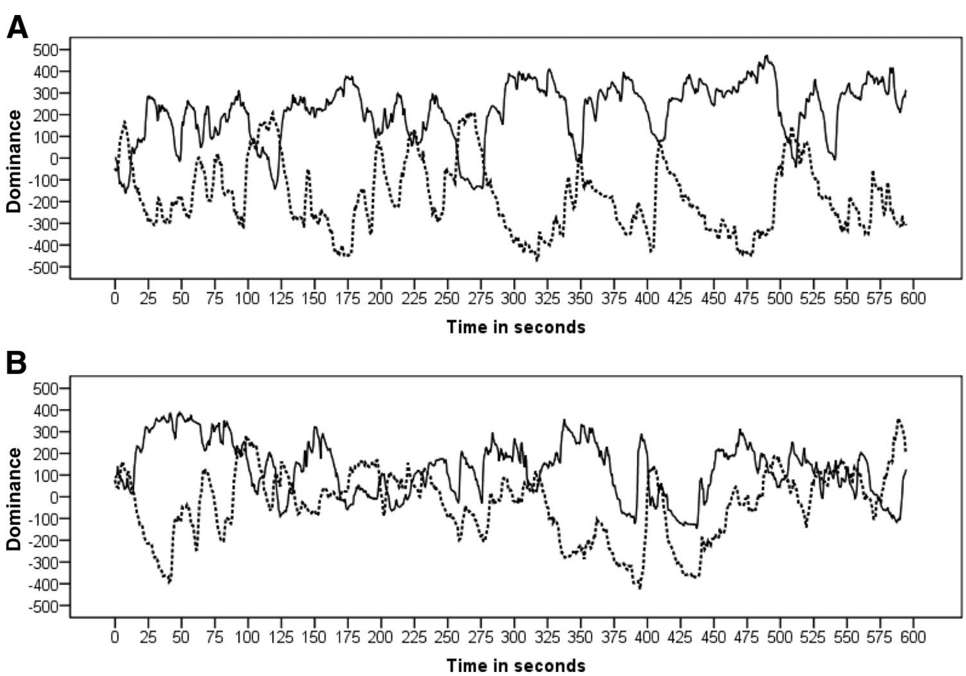


*Figure 3.* Two examples of bivariate time series of woman's dominance (solid) with man's dominance (dotted).

dominance, 40 (80%) showed a very clear low point (maximum negative correlation) at the lag of zero, with the correlation typically heading toward zero fairly sharply at increasing lags in each direction. A further six CCFs (12%) showed a modest low point at lag 0, with a somewhat more negative trough elsewhere, located inconsistently across these dyads. For both affiliation and dominance, the few remaining CCFs tended to lack prominent peaks.

Thus, in the vast majority of the dyads, the predominant type of interrelatedness for both affiliation and dominance occurred at and around a lag of zero. Hence, the unlagged cross correlation should be an appropriate overall index of complementarity in these data. (In the next section, we provide a specific analysis of time lags, expressed as phase.)

### *Fine-Grained Evaluation of Interpersonal Complementarity: Spectral Analyses*

As mentioned previously, cross correlations can reflect at least three types of separable components: (a) shared trends over time (e.g., if both partners' behavioral levels increase over time, this can produce a large positive cross correlation), (b) cyclical patterns that are in synchrony between the partners (e.g., oppositely phased cycles between partners can produce a large negative cross correlation), and (c) associations between the partners' "random" behaviors (that is, ones that cannot be predicted by trends and cycles). These three types of statistical interdependence are logically distinguishable (Cappella, 1996) and can be isolated to study their separate contributions using procedures based on spectral analysis, as outlined by Warner (1998).

*Linear trends.* The first step is to model and remove overall trends. Using a regression analysis for each univariate time series, we derived the intercept at the beginning of the series, which indexes the average level at the start of the 595-s period, and the linear slope, which indexes overall change over this same period. Table 2 provides descriptive statistics across the 50 dyads, which show fairly large individual differences in both intercepts and slopes. On average, linear trend (slope) accounted for 18% and 19% of the variance in affiliation for women and men, respectively (with individual values ranging from 0% to 70%), and for 10% and 9% of the variance in dominance for women and men, respectively (with a range from 0% to 43%).

Of particular interest are the correlations of the regression coefficients across the partners. Men's and women's intercepts (that is, an estimate of their level at the beginning of the 10-min period) were strongly correlated: For affiliation, the correlation of men's and women's intercepts was .71 ($p < .001$); for dominance, the correlation was $-.71$ ($p < .001$). Given that partners were unacquainted and randomly paired at the beginning of the study, these correlations show that partners had made quite a lot of mutual adjustment of style, consistent with interpersonal theory, by the beginning of the 10 min under study in the time series. These adjustments of overall level represent one important component of complementarity. (In contrast to the foregoing results, the intercepts were not significantly correlated across affiliation and dominance; the correlations ranged from .01 to .16.)

Also in accordance with interpersonal theory, men's and women's slopes were significantly correlated: For affiliation, $r = .34$, $p < .05$; for dominance, $r = -.42$, $p < .01$. These results suggest that some further mutual interpersonal adjustment is continuing to occur over the 10-min period under study.

*Spectral and cross-spectral analyses.* Using spectral analysis, the detrended data may be examined to determine the presence of any cycles; then, using cross-spectral analysis, the extent of synchrony between partners in these cycles may be determined (Kenny, Kashy, & Cook, 2006). We performed these analyses separately on each dyad and then combined the resulting statistics over the entire sample of 50 dyads. Before presenting the results, we briefly describe the various indices derived from these spectral analyses.

From a spectral analysis of each detrended univariate time series, we computed an index of rhythmicity (the degree to which a person's variability lies within a relatively small number of cyclic components). In accordance with previous research (Lester, Hoffman, & Brazelton, 1985; Wade, Ellis, & Bohrer, 1973; Warner, 1998; Warner, Malloy, Schneider, Knoth, & Wilder, 1987), the rhythmicity index is the proportion of variance contained in the low-frequency end of the spectrum, for cycles longer than 0.5 min. The 0.5-min cutoff was chosen because higher frequencies made only relatively trivial contributions (each explaining less than 1% of the variance). Figure 4 shows this cutoff applied to the spectral-density distributions for affiliation and dominance averaged across the women; the corresponding graph for men was very similar. (For this figure, as well as in Figures 5 and 6, frequency, along the *x*-axis, is expressed as the period, or the length of time in seconds for one cycle.) For each dyad, the intercept, slope, and rhythmicity were calculated separately for all

Table 2
*Summary Statistics for Intercepts and Slopes of the Time Series*

| | Affiliation | | | Dominance | | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | Range | *M* | *SD* | Range |
| Intercept | | | | | | |
| Women | 222.25 | 141.38 | −117.81 to 519.73 | 57.62 | 184.31 | −351.90 to 432.04 |
| Men | 167.64 | 136.75 | −119.62 to 423.81 | 32.46 | 217.91 | −470.05 to 551.07 |
| Slope | | | | | | |
| Women | 20.15 | 171.78 | −543.04 to 298.13 | 25.81 | 180.87 | −363.61 to 387.72 |
| Men | 37.17 | 164.36 | −658.74 to 357.83 | 14.60 | 181.28 | −376.08 to 416.70 |

*Note*. Slope is the linear change over the full 595-s time series.

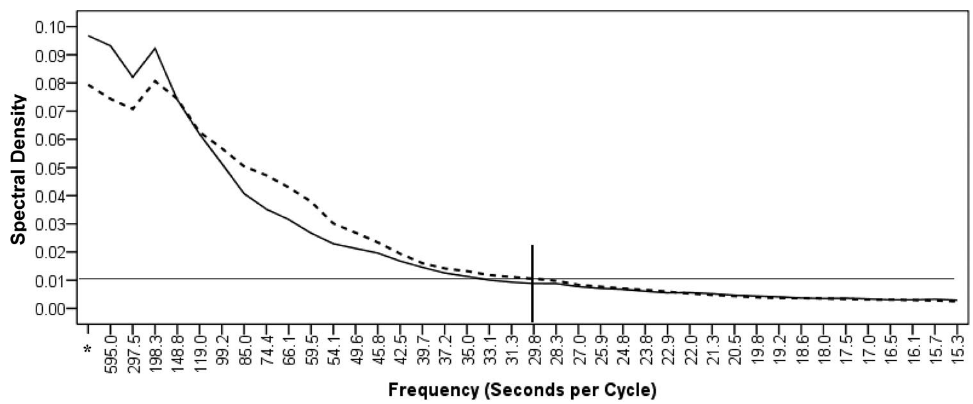


*Figure 4.* Spectral density averaged across women: affiliation (solid) and dominance (dashed). Note that the smoothing performed by the spectral analysis extrapolates back to a frequency of zero, denoted here by an asterisk (because there is no corresponding period length).

detrended time series: for the woman's affiliation, the man's affiliation, the woman's dominance, and the man's dominance.

To index the degree and nature of coordination of behavioral cycles between partners, we performed a cross-spectral analysis on each detrended bivariate time series. As the overall index of coordination or entrainment between partners, we computed the average weighted coherence over the low-frequency end of the spectrum for cycles longer than 0.5 min. In accordance with recommendations by Porges et al. (1980) and Warner (1998), we computed this average by weighting the coherence estimate at each frequency band by the amount of variance in the univariate spectra at this frequency. The resulting average weighted coherence, which varies from 0 to 1, indexes the proportion of variance that can be predicted from cycles in either time series by the other time series (like a squared correlation). It is thus a nondirectional measure of influence (Gottman, 1981), indexing attuned or shared cycles (Cappella, 1996; Chapple, 1970; Field, 1985; Warner, 1988).

From the cross-spectral analysis on each bivariate time series, we also computed the average phase relationship over the low-frequency end of the spectrum, for cycles longer than 0.5 min. As suggested by Warner (1998), we expressed phase as the fraction of a full cycle by which the peaks in partners' behaviors are separated. A value of 0 indicates that the two partners are exactly in phase, with peaks in their cycles coinciding, whereas a value of 0.5 indicates that the two partners are exactly opposite in phase, with peaks for one person occurring at the same time as troughs for the other person. In accordance with interpersonal theory, the concept of sameness in affiliation implies a phase of 0, and the concept of oppositeness in dominance implies a phase of 0.5 (or equivalently −0.5, because phase values of −0.5 and 0.5 are logically indistinguishable).[4] Intermediate values are also possible, with, for example, a value of 0.25 indicating that peaks for one person occur a quarter of a cycle ahead of peaks for the other person. (A positive sign indicates that peaks for the woman lead peaks for the man; a negative sign indicates the opposite.)

Table 3 presents summary statistics for the foregoing indices, computed across the entire sample of 50 dyads. For both women and men, the rhythmicity index shows that, on average, more than 80% of the variance in the time series was attributable to relatively low-frequency cycles (longer than 0.5 min); in addition, the distributions of individual differences around these means appear to be fairly tight. Thus, cyclical tendencies characterize the data quite well.

The extent of between-partners synchrony of these cyclical behaviors is indexed by the weighted coherence, the means for which indicate substantial overall attunement of cycles between partners for both affiliation and dominance.[5] Nonetheless, dyads varied considerably in their degree of synchrony; the range extends from close to zero (the minimum possible value) to close to one (the maximum possible value). It is also of interest that, across the 50 dyads, the correlation of the weighted average coherence for affiliation with that for dominance was −.03. Thus, consistent with interpersonal theory, behavioral synchrony on affiliation is orthogonal to behavioral synchrony on dominance.

Finally, mean values for the average phase were exactly as predicted by interpersonal theory. For affiliation, the mean across all dyads has a 95% confidence interval of −.01 to .02. Thus, on average, dyads tended to cycle in their levels of affiliation almost perfectly in phase (such that the partners' peaks occur at the same time). For dominance, the mean across all dyads has a 95% confidence interval going from −.47 to −.5, where the values of −.5 and .5 have the same meaning, and then from .5 to .49. Thus, dyads tended to cycle in their levels of dominance almost perfectly opposite in phase (such that one partner's peaks occur at the same time as the other partner's troughs). As indicated by the ranges in Table 3, there was no overlap at all in the distributions for average phase: On the basis of phase alone, one could tell with perfect

[4] The range of possible values for the phase is circular, with .5 and −.5 falling at the same point on the circle, exactly opposite (180 degrees) from the value of 0.

[5] In parallel with our approach to the cross correlations, the distribution of the average weighted coherence values for all possible female–male pseudo-dyads may serve as one possible standard of comparison for the values obtained from the real dyads. The average weighted coherence for the pseudo-dyads yielded a mean of .26 and a standard deviation of .15 for affiliation, and a mean of .23 and a standard deviation of .12 for dominance. Thus, both means for the real dyads fall more than one standard deviation above the means of these pseudo-dyad distributions.

Table 3
*Summary Statistics for Spectral and Cross-Spectral Analyses*

| | Affiliation | | | Dominance | | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | Range | *M* | *SD* | Range |
| Woman's rhythmicity | .83 | .07 | .61 to .95 | .84 | .07 | .59 to .95 |
| Man's rhythmicity | .83 | .07 | .65 to .92 | .85 | .05 | .71 to .98 |
| Weighted coherence | .51 | .23 | .07 to .94 | .38 | .20 | .07 to .89 |
| Average phase | .01 | .05 | −.19 to 0, 0 to .13 | −.49 | .06 | −.34 to −.5, .5 to .34 |

accuracy whether any bivariate time series is for affiliation or for dominance.

In a sense, the average weighted coherence is a relatively high-level abstraction based on the results of the spectral analyses. To appreciate more fully how the spectral and cross-spectral analyses handle the data from each dyad, it is worthwhile to look briefly at graphs of the spectral and cross-spectral results for the particular dyads whose time series appear in Figures 2 and 3. Figure 5A shows graphs of the spectral densities and the coherence for the affiliation time series depicted in Figure 2A; likewise, Figure 5B depicts the spectral results for the affiliation time series in Figure 2B. The graphs of the spectral density, on the left, show the proportion of the total variance of each partner's time series at each frequency (cycles with periods from 595 s to 31 s). The graphs on the right show the corresponding values of the coherence, whose possible range is 0 to 1.

For the dyad depicted in Figure 5A, the profiles of the spectral density for each partner closely resemble each other, with a major peak centered at 198 s per cycle and some suggestion of a minor, higher frequency peak roughly around 50 s per cycle. In addition, the coherence around each of these frequencies is extremely high (>.85); the net result is an average weighted coherence of .87. In contrast, for the dyad depicted in Figure 5B, the woman's peak spectral density centered at 119 s per cycle lies at a higher frequency than most of the man's profile. In addition, the levels of coherence at the relevant, relatively low frequencies are fairly low (<.45); the net result is an average weighted coherence of .27.

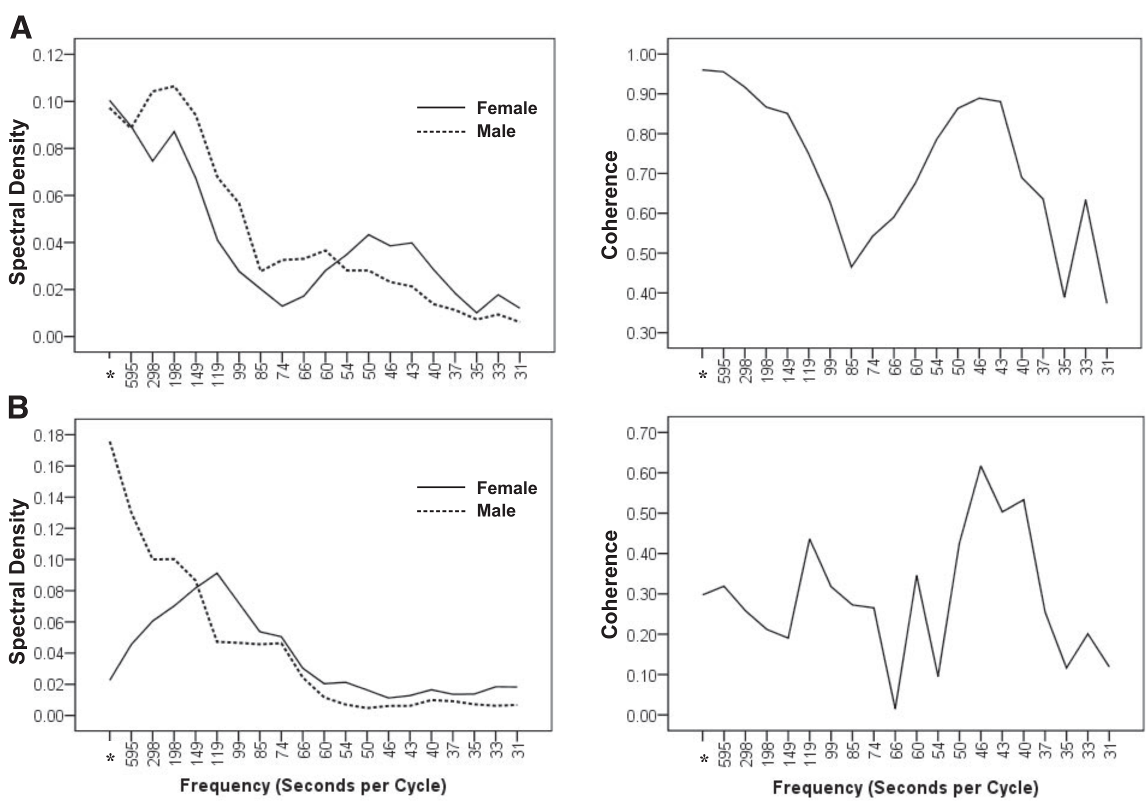


*Figure 5.* Spectral density (proportion of variance) and coherence for the two examples of affiliation time series. Note that the smoothing performed by the spectral analysis extrapolates back to a frequency of zero, denoted here by an asterisk (because there is no corresponding period length).

Figure 6A shows graphs of the spectral densities and the coherence for the dominance time series depicted in Figure 3A; likewise, Figure 6B depicts the spectral results for the dominance time series in Figure 3B. For the dyad depicted in Figure 6A, the profiles of the partners' spectral density share a strong peak centered at 99 s per cycle, and the coherence around this frequency is very high (>.85); the net result is an average weighted coherence of .80. In contrast, although both partners in the dyad depicted in Figure 6B have substantial spectral densities in the range of cycles of 298 s to 149 s duration, the corresponding coherence values are extremely low (<.15), yielding an average weighted coherence of .14.

*CCFs between prewhitened residuals.* Finally, to examine associations between the partners' "random" behaviors, we prewhitened each time series (in the sense that the resulting data resemble "white noise") to remove trends, cycles, and other forms of serial dependence. Specifically, following recommendations by Warner (1998), we modeled each time series with a second-order autoregressive model, in which the value at each time point is predicted by the previous two values ($t - 1$ and $t - 2$). In the vast majority of cases, this second-order model was sufficient to yield residuals with nonsignificant serial dependence ($p > .05$), as assessed by the Box-Ljung $Q$ test. We then calculated the lagged CCFs interrelating the pairs of residuals for each dyad: woman's affiliation level with man's affiliation level and woman's dominance level with man's dominance level. These lagged cross correlations detect any interrelated patterns across partners' moment-to-moment "random" variations—that is, variations away from each person's predictable trends and cycles.

The second-order autoregressive model left only a very small amount of variance in the residuals—an average of 2% for affiliation and only 1% for dominance. Nonetheless, after we controlled for serial dependence within each time series, there was virtually always a significant peak in the lagged cross correlations at a zero time lag, or else within 2 s of it. After we controlled for serial dependence within each time series, there remained a statistically significant positive cross correlation between partners' affiliation levels for 49 of the 50 dyads (average $r = .15$). Likewise, there was still a statistically significant negative cross correlation between partners' dominance levels for 49 of the 50 dyads (average $r = -.13$). There was no consistent tendency for a significant cross correlation to occur at any other time lag, and most dyads showed little indication of any relation away from a lag of zero.

### Other Results

Across the 50 dyads, for both affiliation and dominance, the raw and detrended cross correlations for the unprewhitened data correlated strongly with the weighted average coherence: for affiliation, $r = .74$ for raw and .79 for detrended; for dominance, $r = -.76$ for raw and $-.82$ for detrended. These results show that the

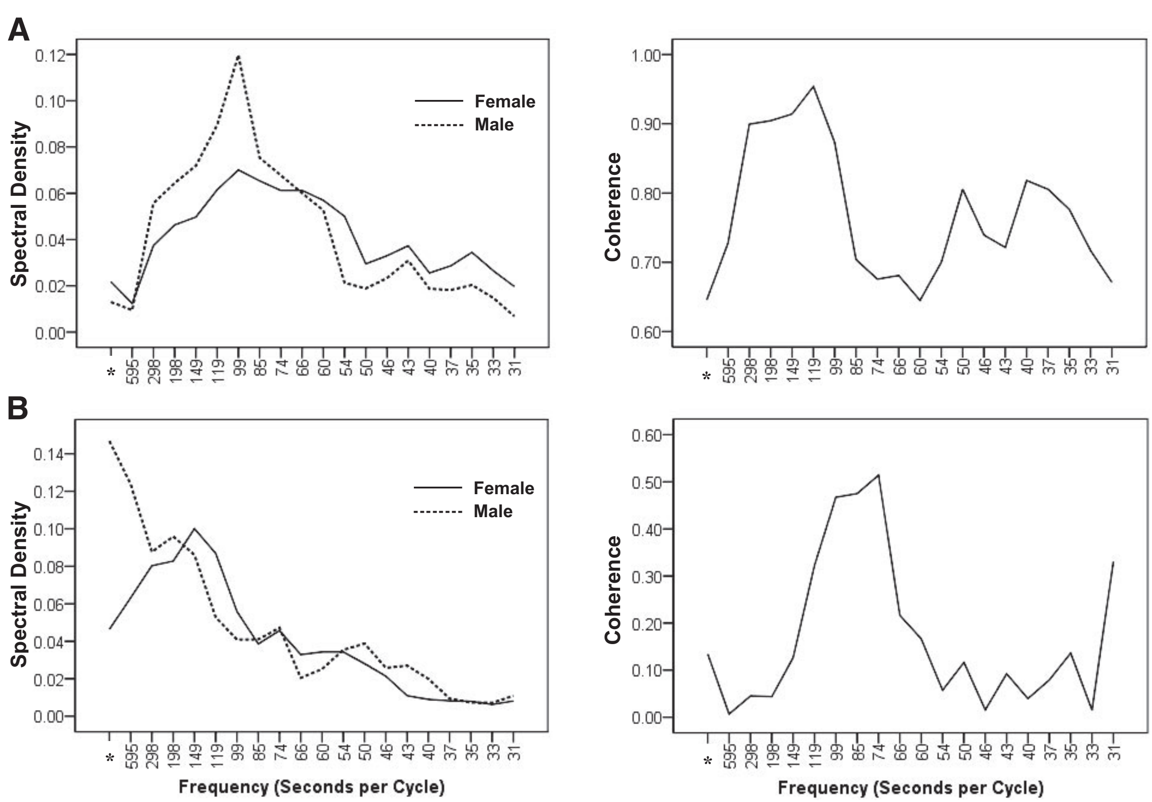


*Figure 6.* Spectral density (proportion of variance) and coherence for the two examples of dominance time series. Note that the smoothing performed by the spectral analysis extrapolates back to a frequency of zero, denoted here by an asterisk (because there is no corresponding period length).

unlagged cross correlation is principally indexing synchrony between relative low-frequency behavioral cycles.

In addition to the cross correlations, which were of particular relevance to interpersonal theory, we also computed, on an exploratory basis, four unlagged cross correlations between affiliation and dominance levels: (a) the woman's affiliation with her own dominance, (b) the man's affiliation with his own dominance, (c) the woman's affiliation with the man's dominance, and (d) the woman's dominance with the man's affiliation. Table 4 shows that, although all four of these cross correlations have means significantly greater than zero, their overall magnitudes are modest. However, the ranges suggest substantial individual differences, which may be of interest in further research.

Finally, across all the results there were no statistically significant sex differences, with just one exception: The intercept for affiliation was higher for women than for men ($p < .001$; see Table 2).

## Discussion

This study evaluated two crucial hypotheses about the nature of interpersonal complementarity. First, on the basis of the mutual-adaptation literature, as well as speculations by Kiesler (1996) and other interpersonal theorists, we proposed that a major form of interpersonal complementarity would be the presence of shared cyclical patterns of behavior occurring within an interaction. Second, also on the basis of the mutual-adaptation literature, we proposed that these shared cyclical patterns would be empirically distinguishable from two other possible forms of complementarity: mutual adjustments in overall level (such as the mean level of affiliation during an interaction) and noncyclical, random effects of partners' behaviors on each other. Overall, the results of the study lend very strong support to these hypotheses.

### *Interpersonal Complementarity as Shared Cyclical Patterns*

One line of evidence for shared patterns is that the moment-to-moment correlations between partners' streams of behavior indicated strong interrelatedness for the vast majority of dyads. Consistent with interpersonal theory, for almost all dyads, the correlation between partners' affiliation behaviors was positive, and the correlation between their dominance behaviors was negative. In support of the interpretation of these cross correlations as indicating the nature of behavioral coordination between partners, we showed that the correlations were not simply an artifact of autocorrelation within each time series, not solely a reflection of shared linear trend, and not concealing other, time-lagged relations.

Another converging line of evidence came from the spectral and cross-spectral analyses, which revealed that the foregoing cross correlations mainly reflect shared cyclical patterns of behavior within the interaction. These shared cycles have three essential qualities: frequency, coherence, and phase. First, attuned or entrained partners tend to be on the same "wavelength": Their behaviors cycle at roughly the same frequency. These frequencies differed somewhat from one dyad to the next but were consistently of relatively low frequency, typically peaking somewhere in the range of approximately 1.5–3.3 min. Second, for attuned or entrained partners, these same-frequency cycles have strongly correlated variations in amplitude, as measured by coherence. Third, these coherent cycles have very distinctive phase signatures: Consistent with interpersonal theory, affiliation behaviors were very strongly in phase (going up and down together), and dominance behaviors were equally strongly opposite in phase (one partner going up as the other goes down, and vice versa).

It is important to point out that simple turn-taking cannot account for the oppositely phased dominance cycles. Cappella (1996) showed that a set of correlated behaviors indexing turn-taking yielded cycles of a few seconds, at most, which is a much higher frequency than the dominance cycles we obtained. Cappella was able to show that there was dynamic adaptation between partners, even when covarying out such turn-taking cycles. In a similar fashion, our spectral and cross-spectral analyses exclude such high-frequency phenomena, because the rhythmicity indices, average weighted coherence, and average phase relationship were computed over the low-frequency end of the spectrum (for cycles longer than 0.5 min).

Nonetheless, the range of periods for dominance cycles found in our study is roughly comparable to the periods of approximately 1–2 min found in some previous studies of variation in vocal activity (Cobb, 1973; Hayes & Cobb, 1979; Warner, 1979). To distinguish these cycles from simple turn-taking, Dabbs (1983) called them "megaturns," a term that denotes a broader form of control in an interaction. Each "megaturn" for the dyads in our study would consist of several conversational interchanges, not simply one person holding the floor.

### *Other Forms of Interpersonal Complementarity*

The strong shared cyclical patterns of behavior we found were empirically distinct from two other forms of interpersonal complementarity, each of which was isolated in other results. First, the presence of mutual adjustments in overall level between partners was shown by the linear trend analysis. The very strong correlation between partners' intercepts (denoting their level of behavior at the beginning of the 10-min period under study) indicated that strong mutual adaptation of overall level had already occurred in the first 10 min of their interaction. Consistent with interpersonal theory, this correlation was positive for affiliation and negative for dominance. In addition, partners' slopes over the subsequent 10-min

Table 4
*Summary Statistics for Detrended, Unlagged Cross-Correlations of Affiliation With Dominance*

| | *M* | *SD* | Range |
|---|---|---|---|
| Within partners | | | |
| Woman's affiliation with woman's dominance | .17* | .25 | −.45 to .61 |
| Man's affiliation with man's dominance | .23* | .26 | −.37 to .72 |
| Between partners | | | |
| Woman's affiliation with man's dominance | .17* | .23 | −.48 to .63 |
| Man's affiliation with woman's dominance | .11* | .20 | −.37 to .47 |

* $p < .001$.

period under study were also correlated, positively for affiliation and negatively for dominance, indicating modest further mutual adjustments in overall level. These findings lend additional support to the predominant form of interpersonal complementarity found in previous studies, including ours (e.g., Sadler & Woody, 2003).

Second, a very consistent, if low, level of association between partners' noncyclical, random behaviors was evident in the analyses of the CCFs between prewhitened residuals. Again supporting interpersonal theory, the direction of this association was positive for affiliation and negative for dominance. These kinds of residual associations have been interpreted as indicating processes of interactive repair (Tronick & Gianino, 1986). There was no consistent asymmetry (lead–lag relation) in these associations, which may possibly suggest that the underlying process occurs too quickly for observers to pick up a time lag. However, in extensive work with time-series analyses of dyads, Cappella (1996) also predominately found simultaneous effects, rather than lagged ones. One explanation would be that partners may be largely responding to each other's anticipated, rather than actual, behavior, akin to what would be required in a synchronized dance. Lags may also be less characteristic of the interaction patterns of relatively equal partners, unlike, for example, mother–infant interactions.

However, the prewhitened residuals captured only a tiny proportion of the variance in the time series, in comparison with the linear trends and especially to the cycles. As Warner (1998) remarked, "Shared trends or cycles . . . may be the basis for the coordination of behavior. If we remove or ignore trends or cycles, we may be removing the most interesting aspect of the information" (p. 125). Similarly, Burgoon and colleagues (1995) have hypothesized that, over a broad range of conditions, "most interaction patterns will oscillate" (p. 264).

It is important to keep in mind that the foregoing constellation of results characterize unacquainted mixed-sex dyads working on an open-ended, collaborative task in which the roles of the partners are not constrained in any way (e.g., neither member of the dyad was designated as the leader). We know from previous work (Sadler & Woody, 2003, 2007) that this paradigm generates interesting interpersonal processes, and hence, it was a solid starting point for investigating the potential of newer data-analytic techniques. Nonetheless, how other types of dyads and tasks might alter the dyadic processes found in this study is an interesting and important empirical question. For example, a competitive task might evoke closely coupled cyclical patterns of a somewhat different form, and there is some reason to anticipate that synchrony may be particularly important in interactions where there is the possibility of romantic interest (Grammer, Kruck, & Magnusson, 1998).

### *Further Potential of the Joystick Method for Studying Interactions*

We showed that, compared with a multi-item inventory such as the SBI, the joystick method captures the overall or mean level of interactants' interpersonal behaviors very well. This convergent validity is noteworthy because the cognitive task facing observers in the two approaches is quite different. Using a behaviorally anchored multi-item inventory, the rater must mentally aggregate observed behavior over the entire time period of the interaction; however, any aggregation of the different behavioral cues is handled in the data analysis (such as by summing ratings on the items). In contrast, using the joystick method, the rater must mentally aggregate the different behavioral cues on a moment-to-moment basis; however, any aggregation over time (or other time-related processing) is handled in the data analysis.

Some advantages of the joystick method stem from this flexibility in the handling of time. For example, the stream of behavior over the course of an interaction could readily be split into subsegments to study changes. For this purpose, a useful addition to the joystick apparatus might be the option to annotate the time series by marking critical incidents, such as by using the "firing" button on the joystick. Critical incidents may be thought of as discontinuous, possibly nonrecurring events that might shift properties of the time series, such as the overall level.

However, the most noteworthy advantage of the joystick method is that it allows us to go beyond overall level and study patterns of variability and interpartner coordination that occur within an interaction. Generally, in the present article, we have emphasized the considerable commonalities across dyads in these patterns over time. However, time-series-derived indices—such as the cross correlation, average weighted coherence, and average phase—may have considerable potential for measuring meaningful and important differences between dyads. For example, some dyads in the present study showed extremely close coordination in dominance, whereas others showed virtually none. In future research, such differences may relate fruitfully to a wide variety of possible external variables, such as the qualities of relationship and collaborative work outcomes. For example, Markey, Lowmaster, and Eichler (in press) have recently used the joystick methodology to show that positive across-partner correlations in affiliation relate to faster completion and better quality of collaborative tasks (see also similar work in the mutual-adaptation literature, discussed by Cappella, 1996).

Another promising application would be to use the time-series-derived indices to characterize the interaction patterns of people with interpersonal forms of psychopathology. Although such indices mainly index dyadic, rather than individual, functioning, they are appropriate for this purpose, because people with interpersonal pathology are hypothesized to exert undue and counterproductive influence in their interactions with others (Kiesler, 1996).

In its capacity to capture patterns over time, the time-series analysis of joystick data somewhat resembles sequential analysis (e.g., Bakeman & Gottman, 1997). However, the differences are considerable. For sequential analysis, the flow of behavior must be chopped into many discrete observation units, each of which must be separately rated, typically with categorical codes (that are most often dichotomous). In contrast, the joystick method is not only much more expedient, but it records behavior as a stream that is reasonably continuous across time, and the rating at each specific time is also reasonably continuous (as indicated by a position along axes on a scale of $-1,000$ to 1,000). Another important difference is the role of context. In sequential analysis, each observation unit is typically rated in a decontextualized way as a separate entity; context reappears, in a sense, only through prediction using a small number of immediately preceding units (e.g., $t - 1$ and $t - 2$). In contrast, the joystick method makes full use of the observers' expertise about the relevant context for the current behavior, which may extend well beyond the immediately preceding behavior. Consider, for example, an interactant's reintroduction of an earlier topic: The observer's appraisal of the interpersonal significance of this behavior would be affected by whether, for instance, the partner had refused in an annoyed way to consider this topic a while earlier. Because observers attend to multiple channels of behavior, they can also take account of instances in which one channel's message disqualifies another's (Burgoon, 1985).

The possible downside of this use of the observers' interpersonal expertise is the possibility that the results could partly reflect their expectancy-based biases. To limit this possibility, we trained the observers to attend carefully to specific, relevant behaviors of the target person, and we aggregated across multiple observers to attenuate idiosyncratic perceptions. However, the issue of bias can also be viewed constructively, in that another possible use of the joystick method would be to study, in fine detail, individual differences in the patterns of social perception by nonexpert participants. The interpersonal literature offers relevant hypotheses about likely biases in social perception that may be linked to various types of interpersonal difficulties (e.g., Kiesler, 1996), and the aggregated time series of expert observers could be used as the criterial benchmark. Moreover, the joystick method also lends itself to studying the interrelation of social perceptions between interactional partners. Following an interaction, each partner could watch the interaction and rate the streams of behavior of oneself and one's partner, and then the interrelation of these perceptions across partners could be examined. Such interrelations are very consonant with recent interest in situated social cognition (Smith & Semin, 2007) and the role of synchronization and coregulation in social cognition (Semin, 2007; Semin & Cacioppo, 2008).

Interaction data using the joystick method also answers Boker's (2002, p. 405) "call on the hunting horn" for the measurement of psychological constructs as continuous, differentiable trajectories over time (that is, trajectories for which an instantaneous slope exists at every time point). Such representations of interpersonal variables open the door to other exciting and innovative data-analytic approaches. One is windowed cross correlation and peak picking (Boker, Xu, Rotondo, & King, 2002), which could be used to examine whether there are important changes in the magnitude of the cross correlation and the associated time lags over the course of an interaction. Another is nonlinear dynamic models (e.g., Boker & Wenger, 2007), in which the coupled dynamics of interactants may be studied as regularities between derivatives. These future possibilities make use of the ability of the joystick method to provide a continuous representation of how interaction behavior changes over time.

### A Rapprochement Between Two Literatures

Finally, we hope that the present work demonstrates the considerable potential of a rapprochement between the mutual-adaptation and interpersonal-theory literatures, with their complementary strengths. Interpersonal theory, with its strong roots in personality and psychopathology, offers the thorough conceptualization and measurement of relevant individual differences, such as expectancies, values, and preferred styles, as well as a sophisticated theory of interpersonal maladjustment and the cognitive factors that maintain maladaptive patterns (e.g., Kiesler, 1996). The mutual-adaptation literature, with its strong roots in communication research, offers a rich source of hypotheses about the specific mechanisms and channels underpinning effective communication and the specific ways that communication patterns can go astray (e.g., Burgoon et al., 1995). The two were meant for each other.

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