

## An Ecological Examination of Rapport Using a Dyadic Puzzle Task

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**ABSTRACT.** Previous studies have indicated that situational context impacts the rapport experience (e.g., F. J. Bernieri, J. S. Gillis, J. M. Davis, & J. E. Grahe, 1996; N. M. Puccinelli, L. Tickle-Degnen, & R. Rosenthal, 2003). The authors designed the present study to further document the behavioral and experiential predictors of dyadic rapport and to evaluate dyadic rapport experiences when contributions were required from both interactants. Participants ( $N = 60$ ) were paired into dyads and instructed to complete children's puzzles. However, the dyadic members were restricted in how they could accomplish this task: Only one interactant was allowed to work on the puzzle and had to do so blindfolded, while the second interactant gave instructions. Results suggested that less attribution of responsibility to the worker and the instructor's experience of enjoyment and frustration were indicative of higher rapport. Other characteristics of dyads reporting higher dyadic rapport included difficulty completing the task and more communicative behavior. The results provide important information for the understanding of the dyadic experience of rapport.

**Keywords:** group process, interpersonal theory, interpersonal understanding, rapport, social interaction, social perception

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**DYADIC RELATIONSHIPS** are a key interpersonal category, as they represent the primary component of many social structures. For example, loving couples are the primary component of most families; the teacher–student relationship is the primary component of the educational system; and the client–practitioner relationship is the primary component of clinical relationships. The success of these relationships relies on the contributions of both parties. Although the shared

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responsibilities are not necessarily distributed evenly, none of these relationships can function if only one person contributes. However, researchers focusing on dyadic relationships frequently look at activities that can be dominated by one of the individuals in a dyad.

Although most dyads in laboratory settings do display contributions from both interactants, the structure of the laboratory is different than that of practical settings. In the relationships described above, there are serious consequences (e.g., divorce, academic failure, unsuccessful clinical treatment) when one party fails to contribute to the group. Such potential negative outcomes increase each party's motivation to act in the best interest of the dyad. In laboratory relationships, there are rarely costs for lack of contribution. If one individual makes little effort to complete the assigned activity, the worst that might happen is that the participant's partner in the experiment becomes angry or frustrated. Relationships that dissolve at the end of a half-hour interaction possess few costs or rewards for lack of effort or hard work, perhaps resulting in uneven contributions to the task (i.e., social loafing; Williams, Harkins, & Latané, 1981). The dyadic puzzle task in the present study required the contributions of both parties, thereby encouraging increased dyadic activity.

#### *Rapport as a Barometer of Dyadic Relationships*

Researchers have proposed that rapport can be used as a measure of the quality and effectiveness of dyadic relationships (Bernieri, Gillis, Davis, & Grahe, 1996; Tickle-Degnen & Rosenthal, 1990). According to Tickle-Degnen and Rosenthal, *dyadic rapport* reflects the combined effects of the interactants' mutual attention, mutual positivity, and coordination. Increased rapport should be indicative of better functioning dyads or, at the very least, more positive relationships.

The *Brunswikian Lens Model* is a method of studying perception that addresses three distinct issues: (a) *ecology*, or how behaviors are encoded on the criterion; (b) *cue utilization*, or how behaviors are decoded through judgments; and (c) *achievement*, or the relationship between the criterion and the judgments. Although Brunswik (1955) originally proposed his Lens Model to address object perception, researchers have recently adopted it to study person (Gifford, 1994) and social (Bernieri et al., 1996) perception, typically by measuring the relationship between the individuals' experiential reports and the behaviors manifested during the interaction. Thus, researchers can learn about what a construct looks like by determining what behaviors predict the dyads' perceptions of the event. Researchers can use the same methods to evaluate the relationship between other perceptions of the interaction. For instance, Tickle-Degnen and Rosenthal (1990) proposed that mutual attention, mutual positivity, and coordination are related to rapport. However, the question remains whether a dyad perceives this relationship. Though theorized (see Tickle-Degnen & Rosenthal), little empirical work has examined this. In the present study, we evaluated this premise and also

looked at how participants perceived the relationship between rapport and other psychological constructs, such as frustration and enjoyment.

### *Rapport Behaviors and the Interaction Context*

As important as it may be to understand how individuals in an interaction perceive the experience of rapport, it is also important to evaluate the behaviors that manifest rapport. By identifying behaviors that indicate higher rapport, researchers can provide a mechanism to evaluate, from an external perspective such as that of a marriage counselor or a work supervisor, whether a dyad is experiencing rapport. In addition, understanding how rapport is manifested can suggest ways to improve rapport in others.

One such mechanism for external evaluation is observing the coordination of the dynamic interplay between interactants. Bernieri, Davis, Rosenthal, and Knee (1994) demonstrated that *postural synchrony*—the similarity and coordinated movement of two individuals' body postures—was associated with increased rapport. In fact, synchrony was one of the few constructs that predicted rapport across both a debate and a trip-planning interaction (Bernieri et al., 1996). More recently, Lakin and Chartrand (2003) linked *mimicry*, or the display of similar behavior between individuals, to increased dyadic rapport experiences. Revisiting Tickle-Degnen and Rosenthal's (1990) proposition that coordination, mutual attention, and positivity are critical to the rapport experience brings to question whether coordination and mutual attention together represent synchrony and/or mimicry. Researchers have demonstrated that unintentional mimicry is linked to increased feelings of rapport (Lakin & Chartrand) and liking in general (Chartrand & Bargh, 1999; Lakin & Chartrand). However, Gada-Jain (1999) demonstrated that when mimicry is intentional, it does not elicit increased rapport. Given the seeming relevance of the synchrony and mimicry construct to rapport, it is important to evaluate whether these factors are related to rapport across different contexts. Furthermore, to fully understand the construct, it is necessary to identify other behaviors that are associated with increased rapport.

Examining rapport in different contexts is important because a basic tenet of social psychology is that changing contexts impacts an individual's behaviors and perceptions. Two groups of researchers have compared behaviors reflecting rapport across different situations (Bernieri et al., 1996; Puccinelli, Tickle-Degnen, & Rosenthal, 2003). Bernieri et al. (1996) measured mixed-sex dyads in two distinct interactions: a debate and a discussion in which participants planned a hypothetical trip around the world. Bernieri et al. (1996) found that the behaviors reflecting rapport experiences changed in the different contexts. Whereas some behaviors, such as dyadic proximity and *interactional synchrony* (the combination of postural synchrony, simultaneous movement, and synchronized movement; Bernieri et al., 1996), consistently predicted rapport in both contexts, other behaviors, such as the frequency of gestures from the female participant, emerged

as predictive of rapport in the debate context but not in the trip-planning context. Overall, the observed behaviors more fully predicted rapport in the debate context than in the trip-planning context.

Puccinelli et al. (2003) also demonstrated that context is important to rapport by evaluating changing perceptions of rapport-related behaviors in multiple contexts. Their participants engaged in a "get to know you" discussion and a puzzle completion task. Their findings indicated that five of six measured variables differed between the two contexts: (a) polite sympathy, (b) critical scrutiny, (c) friendliness, (d) dominance, and (e) status. Though Puccinelli et al. did not report the relationship of these behaviors to the dyads' experiences of rapport, their findings demonstrate that the context of a task influences behaviors related to the rapport experience.

Because the interaction context impacts the quality of the rapport experience, it is important to investigate rapport in multiple contexts to better understand the qualities that lead to increased experience of rapport. In the present study, we measured behaviors that are theoretically linked to rapport (mutual attention, positivity, and coordination), empirically linked to rapport (proximity, gestures), and specific to the task (performance on puzzles, instruction quality) to evaluate the behavioral manifestation of rapport in the context of a dyadic puzzle task.

### *Low Rapport Agreement*

Bernieri and colleagues (Bernieri & Gillis, 2001; Bernieri et al., 1996) concluded that rapport is a dyadic rather than individualistic experience, even though agreement about the rapport experience between dyadic members is weak. They argued that although one individual can have rapport impressions, only the combined experience reflects actual rapport because it emerges from an interaction. This lack of agreement may be attributed to the dyad's limited access to each other's rapport experience (Bernieri & Gillis). The data driving these conclusions came from observing mixed-sex dyads interacting in two contexts: a debate task and a trip-planning task. In both cases, the interactants shared little agreement about their rapport experiences (Bernieri et al., 1996).

It is possible that lack of agreement between interactants about their rapport experiences reflects the fact that rapport is a difficult construct to communicate in a dyad. Researchers have repeatedly demonstrated that some social constructs and traits are more easily communicated and perceived (Funder, 1999; Kenny, 1994). Funder (1999) argued that visibility and relevance were critical components for a trait to be effectively perceived. If rapport is a dyadic experience, manifested by the interaction of two people, it may be difficult for either party in the interaction to actually witness the dyadic experience of rapport. Thus, it might be more accessible to third-party judges than it is to the individuals engaging in the interaction.

By comparing rapport to similar affect-laden constructs, this issue might be clarified. If low dyadic agreement is a function of the context or the dyad's

experience of the situation, then it should be consistent across multiple constructs. However, if rapport is a construct that is particularly difficult for interactants to understand, then agreement about other constructs should be stronger than agreement about rapport. In the present study, we measured constructs methodologically similar to rapport (frustration, enjoyment, and satisfaction) in addition to rapport to determine if agreement is limited by the nature of the rapport construct itself.

Agreement in interpersonal perception is influenced not only by the types of social and personality variables that are being judged but also by the fact that some contexts make behaviors more readable for perceivers (Bernieri, 2001; Funder, 1995). There could also be a limitation in the type of activities (debating and trip planning) previously studied. Dyads function in many contexts and activities. As previously mentioned, some contexts (e.g., marriages or clinical relationships) require both individuals' contributions, whereas others (e.g., two-student papers or fixing a broken object such as a car) can be completed by only one of the dyadic members, even if both are expected to contribute. Although not all clinical relationships elicit the contributions of both parties and not all projects assigned to two people are completed by only one dyadic member, these examples illustrate that contributions to a dyad vary depending on the context. Perhaps this difference impacts the shared experience of rapport. It is possible not only that individualistically driven dyadic interactions result in dyadic members' experiencing less rapport, but also that both members of the duo may be less aware of their partner's rapport experience if they make uneven contributions to the interaction.

Bernieri et al. (1996) asked dyads to engage in a debate and to plan a hypothetical trip around the world. Although these situations encouraged the contributions of both interactants, they did not require equal contributions, because one person can dominate both situations. However, given the nature of a debate, it was likely to elicit more mutual contributions than was the trip-planning assignment. As such, Bernieri et al.'s (1996) finding that the debate situation elicited greater rapport agreement than did the trip-planning situation suggests that mutual dyadic contributions may lead to increased experience of rapport and increased understanding of the rapport experience. If the type of activity limits rapport agreement such that dyadic members experience more rapport in tasks requiring both members' input versus tasks that are more individualistic in nature, then requiring contributions from both members of the dyad should improve rapport agreement. To this end, in the present study we focused on a task that not only encouraged but also required the contributions of both participants.

### *Overview*

In the present study, we further investigated behaviors that manifest rapport, because although context impacts the rapport experience, few interactional contexts have been systematically evaluated. Furthermore, with the impact of context in mind, we aimed to increase the shared rapport experience by constraining the

situational roles to require participation from the complete dyad. Our goal was to eliminate any detracting effects of social loafing on the rapport experience.

To achieve this outcome, we employed a dyadic puzzle task that Grahe, Bernieri, and Gada-Jain (2001) originally developed as part of an interpersonal-perception project. We placed constraints on interactants' completion of children's puzzles such that the participant working on the puzzle was blindfolded and the other participant, who was giving instructions to the worker, was restricted from touching the puzzle, the table, or the worker. These limitations prevented either interactant from completing the task alone. After the interaction, we employed self-reports of various psychological constructs, aspects of performance on the task, and interactant behaviors to evaluate a series of ecological questions related to rapport.

### *Hypotheses*

In this study, we addressed two issues related to the ecology of rapport: (a) the dyadic experience of rapport and (b) the manifestation of rapport in the behaviors and performance of the interactants. For each issue, we both employed exploratory procedures and investigated specific questions derived from previous research. We hypothesized that our findings would further substantiate Tickle-Degnen and Rosenthal's (1990) theory that dyadic rapport is related to increased feelings of mutual attention, mutual positivity, and coordination. We also explored how interactants' rapport experiences related to their experiences of other psychological constructs. Additionally, we examined how rapport was manifested more generally. However, because Bernieri et al. (1996) found that context affected the behavioral manifestation of rapport, we did not make specific predictions regarding the manifestation of rapport beyond the three Tickle-Degnen and Rosenthal constructs.

In addition to examining the two rapport ecology issues, we considered agreement about rapport between dyadic partners. We predicted that the dyadic puzzle task would elicit greater rapport agreement than would the tasks used in previous studies because the context required participation from both parties. By comparing rapport agreement to similar constructs (e.g., enjoyment, frustration), we hoped to further elucidate whether low agreement is due to context or to the dyadic nature of rapport. If context drives agreement, then agreement should be similar for all the affect-laden constructs. However, if rapport is unique somehow, then agreement should be lower on it than on the other constructs.

## **Method**

### *Participants*

We randomly paired 60 students (22 women and 38 men) from a small Midwestern US college into dyads, and they completed this study in exchange for extra credit in a psychology course.

### *Materials and Procedure*

*Children's puzzles.* We used six puzzles for the task. Each dyad received a set of three puzzles. The three puzzles in Set A were (a) "Little Bear 1" with 8 pieces, (b) "Veggie Tales" with 8 pieces, and (c) "Old Woman in the Shoe" with 15 pieces. The three puzzles in Set B were (a) "Little Bear 2" with 8 pieces, (b) "Piglet" with 8 pieces, and (c) "Left/Right Hand" with 12 pieces. In creating these two sets, we ensured that they contained a similar number of pieces and were at a similar difficulty level. Each dyad received one set of puzzles, to be completed in a predetermined order.

*Role assignment.* We randomly paired participants with other students in their introductory psychology laboratory class. Roles were determined by seating: The participant on the right side assumed the instructor role, and the other participant assumed the worker role. The instructor could not touch the puzzle pieces, table, or worker during puzzle completion, and the worker was blindfolded. After the dyad completed each puzzle, the instructor turned over the pieces of the next puzzle to begin. As such, neither participant could complete the task alone: The worker could not do the task without the instructor's sight, and the instructor could not do the task without the worker's ability to move the pieces.

*Postpuzzle questionnaire.* Once the dyads had completed the final puzzle, each member filled out the postpuzzle questionnaire individually, after which we thanked and debriefed them. The questionnaire included 16 questions, which participants rated on an 8-point Likert-type scale ranging from 1 (*strongly disagree*) to 8 (*strongly agree*). Questions focused on participants' impressions of the interaction, including the following constructs: (a) rapport and its 3 theorized components—mutual attention, mutual positivity, and coordination (4 questions, 1 for rapport and 1 for each component); (b) responsibility and cooperation (5 questions); and (c) affective responses such as frustration, enjoyment, and satisfaction (7 questions).

### *Behavioral Coding*

*Performance.* We observed the entire interaction to measure the dyads' performances on the puzzles. Performance variables were: (a) time to complete a puzzle, (b) number of tries to place a piece correctly, and (c) number of commands to complete a puzzle. We created two ratio measurements from these variables: We computed *puzzle effort* by dividing number of tries by the number of pieces in the puzzle and *piece effort* by dividing the number of commands by the number of pieces in the puzzle. To simplify analyses and reduce an already high predictor variable to sample-size ratio,<sup>1</sup> we computed the average score for each behavior across the three puzzles. Generally, behaviors between the three puzzle trials were

not strongly correlated,<sup>2</sup> but the lack of a strong correlation does not limit the improvement in reliability by multiple samples and potentially improves validity (Rosenthal & Rosnow, 1991).

*Interactant behavior.* We videotaped the interactions to allow for behavioral coding. Using the “thin slice” method advanced by Ambady and colleagues (Ambady, Bernieri, & Richeson, 2001; Ambady & Rosenthal, 1992), two coding tapes sampled the dyads’ performances on each of the three puzzles. One tape sampled 30 s from the 2nd min and the other tape sampled 30 s from the 2nd-to-last min of the interaction. We coded two general categories of behaviors from these tapes: objective and subjective. *Objective behaviors* (e.g., smiling) possess operational definitions that identify specific actions that can be easily recognized, whereas *subjective behaviors* (e.g., positivity) possess operational definitions that represent abstract psychological constructs that are commonly understood but are not evident in specific behaviors (Baesler & Burgoon, 1987; Grahe & Bernieri, 2002). We selected most of the behaviors on the basis of whether they were previously identified as predictive of dyadic rapport (see Bernieri et al., 1996), although we chose some because they emerged specifically from this task (e.g., quality of instruction).

As with the performance behaviors, we averaged these variables across the different puzzles and time slices. Most behaviors attained adequate reliability when combined across the six time samples (*Mdn*  $\alpha = .89$ ). Some variables emerged infrequently and yielded low reliability, so we did not include them in subsequent analyses.

## Results

The variables we measured allowed for an examination of the dyadic experience beyond just the construct of rapport. However, given the scope of this paper, we focused our analyses on the rapport experience. We divided the analyses to address the three issues identified earlier: (a) the dyadic experience of rapport, (b) the manifestation of rapport, and (c) the impact of the dyadic task on agreement.

### *Interactant Rapport Experience*

We averaged the individual self-reports of mutual attention, mutual positivity, and coordination to create dyadic factors of each variable. Our first hypothesis was that the dyadic factors of mutual attention, mutual positivity, and coordination would predict self-reported rapport, and we tested this by conducting a regression analysis of the predictability of the interactants’ reported experiences of the dyadic factors on interactants’ reported experience of rapport. This regression demonstrated that these variables reliably predicted rapport, adj.  $R^2 = .62$ ,  $F(3, 26) = 16.74$ ,  $p < .001$ . However, only coordination

( $pr = .61, p < .01$ ) and mutual positivity ( $pr = .56, p < .01$ ) emerged as significant regressors in the equation, whereas mutual attention ( $pr = .46, ns$ ) did not. Because the regression equation was reliable, we created a dyadic rapport variable from the average of the three component variables ( $\alpha = .68$ ). Dyadic rapport was strongly correlated with the single item rapport variable,  $r(30) = .78, p < .001$ . These results suggest that the dyads perceived these variables to be indicative of their rapport experience.

We also computed correlations to explore the relationship between dyadic rapport and the other measured constructs (see Table 1). These correlations demonstrated that dyadic rapport was more closely related to instructor than worker experiences. The only worker experience that was related to rapport was worker responsibility, which was negatively correlated ( $r = -.40$ ). In contrast, responsibility was not related to dyadic rapport in the instructor's experience ( $r = .02$ ). Instead, a positive relationship with enjoyment ( $r = .59$ ) and a negative relationship with frustration ( $Mdn r = -.51$ ) emerged in the instructor experiences. The pattern of correlations revealed higher rapport when (a) the worker did not assume responsibility for performance and (b) the instructor was satisfied with performance, enjoyed the task, and was less frustrated with the dyad's performance.

To evaluate the independent contributions of these variables to rapport, we performed a stepwise regression analysis. When we regressed the self-report variables onto the rapport construct, four variables loaded into a statistically significant regression equation,  $adj. R^2 = .54, F(4, 24) = 9.35, p < .001$ . This regression revealed that, in addition to the instructor's enjoyment ( $pr = .62, p < .001$ ) and lack of frustration at the worker ( $pr = -.50, p < .05$ ), the attribution of responsibility about performance was important. Negative relationships between dyadic rapport and worker responsibility for both the instructor ( $pr = -.09, p < .10$ ) and the worker ( $pr = -.36, p < .10$ ) indicated that dyadic rapport emerged when both parties attributed responsibility of performance to something other than the worker. In contrast, attributions about the instructor's responsibility were unrelated to experienced rapport.

### *Behavioral Manifestation of Rapport Factors*

*Coded behaviors.* We used Pearson correlations to evaluate the relationship between the sampled behaviors and dyadic rapport (see Table 2). Of particular interest were the correlations between the three variables theorized to be components of rapport (mutual attention, mutual positivity, and coordination) and dyadic rapport itself. The correlation analyses yielded mixed results regarding the relationship between these variables and the rapport construct. Both coordination and mutual attention yielded small correlations, and third-party-coded positivity yielded a statistically reliable correlation with instructor positivity,  $r(30) = .39, p < .05$ , but not worker positivity,  $r(30) = .08, ns$ . Furthermore, in

**TABLE 1. Correlations Between Participant Ratings of Experience Variables and Dyadic Rapport**

Dyadic experience variable	Interactant role				Dyadic rapport	
	Instructor		Worker		<i>r</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	Instructor	Worker
Satisfaction	6.57	1.43	6.63	1.19	.48**	.30
Self-responsibility	5.83	1.51	4.59	1.84	.02	-.40*
Partner responsibility	4.60	1.98	6.03	1.61	-.10	-.07
Self-enjoyment	5.73	1.62	5.38	1.78	.59**	.19
Partner enjoyment	4.70	1.86	5.17	1.58	.44*	.18
Frustration at partner	2.63	2.13	2.48	1.84	-.50**	-.16
Frustration at self	4.20	2.46	3.24	2.29	-.52**	-.35*
Partner frustration at me	3.60	2.03	2.86	1.66	-.46*	-.20
Partner frustration at self	3.37	1.99	3.41	2.10	-.54**	-.22

*Note.* Dyadic rapport is a composite variable computed by averaging instructor and worker perceptions of mutual positivity, mutual attention, and coordination. All *r*s are based on *N* = 30 couples.

\*Not significant (*p* < .10).

\*\**p* < .05. \*\*\**p* < .01.

**TABLE 2. Relationships Between Rapport and Sampled Behaviors (Coder-Rated Cues)**

Variable	<i>M</i>	<i>SD</i>	<i>r</i>	<i>pr</i>	<i>t</i> (23)
<i>Instructor</i>					
Objective cues					
Adaptors	1.64	1.85	-.02		
Gestures	4.08	5.72	-.12	-.12	3.27**
Back-channel responses	6.87	3.33	-.02		
Rear lean	5.81	7.82	-.29		
Forward lean	9.37	8.14	.30 <sup>a</sup>		
Subjective cues					
Enjoyment	6.14	1.91	.13		
Expressivity	7.08	2.18	-.05		
Frustration	7.00	1.74	-.22		
Nervous behaviors	3.47	0.55	-.21		
Responsibility	4.80	0.69	.30 <sup>a</sup>		
Positivity	4.47	0.76	.39*	.63	4.97***
Instruction quality	3.44	0.91	.43*		
<i>Worker</i>					
Objective cues					
Back-channel responses	1.10	1.68	.34 <sup>a</sup>	.40	5.26***
Subjective cues					
Enjoyment	6.00	1.91	.09		
Expressivity	5.48	1.66	-.13		
Frustration	6.58	1.83	-.17		
Nervous behavior	3.26	0.39	.05		
Responsibility	4.53	0.44	.06		
Positivity	3.97	0.61	.08	-.44	2.79*
<i>Dyad</i>					
Proximity	7.65	2.77	.21	-.32	2.29*
Coordination	4.07	0.85	.30 <sup>a</sup>	-.24	3.01 <sup>a</sup>
Mutual attention	4.61	0.70	.22		

*Note.* Scores for cues were based on third-party coders' observations of six 20 s "thin slices" (N. Ambady & R. Rosenthal, 1992) of videotapes of participants. Dyadic rapport was a composite variable computed by averaging instructor and worker perceptions of mutual positivity, mutual attention, and coordination. All *r*s are based on *N* = 30 couples.

<sup>a</sup>Not significant (*p* < .10).

\**p* < .05. \*\**p* < .01. \*\*\**p* < .001.

a regression, these four variables failed to adequately predict dyadic rapport,  $R^2 = .24$ ,  $F(4, 25) = 2.01$ ,  $p = .12$ . Together these results provide only weak support for the hypothesis that these three variables are primary to the behavioral manifestation of rapport.

If the theoretically derived behaviors do not strongly predict rapport, can rapport be measured in the interaction? In fact, meaningful behaviors did predict dyadic rapport, including (a) instruction quality,  $r(30) = .43, p < .05$ ; (b) instructor forward lean,  $r(30) = .30, p = .10$ ; (c) instructor responsibility,  $r(30) = .30, p = .10$ ; and (d) worker back-channel responses (e.g., muttering “uh huh”),  $r(30) = .34, p = .06$ . A stepwise regression of the sampled behaviors onto dyadic rapport revealed that six behaviors reliably predicted dyadic rapport,  $\text{adj. } R^2 = .60, F(6, 24) = 8.28, p < .001$ . Table 2 displays the partial  $r$ s for these behaviors. The regression analysis augments the correlation results because instructor gestures ( $pr = -.12$ ), worker positivity ( $pr = -.44$ ), and proximity ( $pr = -.32$ ) emerged as significant predictors. Further, it should be noted that proximity and coordination ( $pr = -.24$ ) reversed signs in the regression compared to the zero-order correlations.

*Performance and rapport.* Performance reflected another type of behavioral manifestation during the puzzle task. Correlations between the performance variables (time, number of tries, number of commands, puzzle effort, and piece effort) averaged across the three puzzle trials and rapport yielded no reliable relationships, all  $r(30)s < .27$ , which suggests that the rapport experience was not directly related to performance on the externally focused dyadic puzzle task.

Together, the results suggest that rapport was encoded in behaviors present during the interaction but not in performance of the task. Additionally, our analyses suggest that dyads experiencing more rapport had instructors who were engaged in the task (e.g., leaning forward, displaying more enjoyment) and communicated beyond the workers' sight limitations (e.g., using fewer gestures, providing better instructions) while the worker was maintaining communication (e.g., providing more back-channel responses).

*Sampled behaviors and dyadic experience.* By interpreting the interaction through how the measured behaviors predicted the dyads' perceptual experiences, we can learn more about which behaviors influenced interactants' perceptions. We accomplished this by examining the correlations between individuals' reported experiences and the sampled behaviors that were manifested during the interaction (see Tables 3–4). We then examined these correlations for the pattern of relationships across all the variables and the specific behaviors that predicted each variable.

The pattern of correlations revealed that the coded behaviors identified some variables better than others. Of the 12 dyadic experience variables, the number of measured behaviors that correlated with each variable (at  $r \geq .30$ ) ranged from 1 to 11 ( $Mdn = 5$ ). Furthermore, the behaviors unevenly predicted the worker and instructor experiences. The 12 worker experience variables were related to 48 behaviors ( $Mdn = 3$  behaviors), whereas the 12 instructor experience variables were related to 10 behaviors ( $Mdn = 1$  behavior). Surprisingly, this result was

inconsistent with how individual experiences were related to rapport, because more instructor experiences predicted dyadic rapport than did worker experiences. Additionally, many of the behaviors, such as instructor adaptors (self-touching behaviors) and instructor forward lean, were visual, and the worker could not have viewed them blindfolded. This indicates that when workers' reported experiences were correlated with visual behaviors (e.g., worker-partner enjoyment and instructor adaptors and rear lean), the workers were recognizing something in the interaction that either was not measured or was conveyed in the instructor's voice or words.

When evaluating the specific behaviors, one question that merits attention is whether the coders' judgments and the interactants' perceptions were related. For instance, if the coders rated a dyad as coordinated, did the interactants report feeling coordinated during the interaction? Of the 22 correlations that measured this relationship, only 2 were positive and significant: (a) coder-rated dyadic coordination and worker-rated dyadic coordination,  $r(30) = .43, p < .05$ ; and (b) instructor frustration at self and instructor frustration at partner,  $r(30) = .36, p < .05$ . This could reflect a number of possibilities, including that the coders' judgments were not valid or that 90 s was not enough time to measure relevant behaviors.

However, with regard to the behaviors that were related to each specific variable, the relationships were generally consistent with what one would expect. For instance, worker perceptions of partner enjoyment were higher when there were fewer instructor adaptors and gestures and when the instructor was not leaning away. Although coded instructor enjoyment did not correlate with worker perceptions, adaptors and leaning away were associated with negative affect (Harrigan, 2005), which suggests a meaningful relationship. Additionally, workers perceived that their partners were frustrated with them when the instructors provided fewer back-channel responses. Again, this would be expected given that fewer back-channel responses probably reflected an instructor who became frustrated and disengaged (see Fargas, 1986). This pattern is consistent across the relationships shown in Tables 3–4.

*Dyadic task and agreement.* Given that rapport was displayed during the interaction, were interactants able to access this information and demonstrate agreement about their psychological experiences? We tested this question by computing correlations between the interactants' dyadic experience variables. For some items (e.g., rapport or satisfaction, tested by asking "How much rapport did we experience?"), this required direct comparison; for other items (e.g., frustration and enjoyment, tested by asking "How much frustration did your partner experience?"), this required us to compare self- and partner reports.

Although we did not include a direct control condition in the present study, estimates from earlier research provide an adequate control ( $r_s = .20-.28$ ; Bernieri & Gillis, 2001) for an indirect test of this hypothesis. Unfortunately, a correlation between instructor and worker self-reported rapport yielded a correlation

**TABLE 3. Correlations Between Coder-Rated Sampled Behaviors and Instructor Self-Ratings of Dyadic Experience Variables**

Dyadic experience variable	Coder-rated behaviors								
	Matt	Wpos	Ipos	Crd	Wrsp	Irsp	Wenj	Ienj	Wfrus
1. Mutual attention	.08	.04	.25	.20	.21	.14	.23	.24	.13
2. Positivity	.03	-.06	.26	.12	.08	-.00	.13	.16	-.14
3. Coordination	.09	-.17	.14	.15	-.14	.18	-.06	-.02	-.12
4. Satisfaction	.26	-.08	.23	.27	.05	.20	-.02	.02	-.25
5. Self-responsibility	-.12	-.08	-.09	-.04	.24	-.11	-.05	-.04	.18
6. Partner responsibility	-.21	-.38*	-.37*	-.36*	-.41*	-.15	-.21	-.21	.27
7. Self-enjoyment	.14	-.07	.16	.22	.25	.15	.08	.11	.06
8. Partner enjoyment	.17	-.16	.03	.19	.13	.14	-.09	-.06	-.07
9. Frustration at partner	-.15	.15	-.13	-.15	.13	-.10	.12	.08	.19
10. Frustration at self	-.21	.16	-.18	-.20	-.10	-.09	.05	-.01	.15
11. Partner frustration at me	-.15	.11	-.13	-.09	.11	-.08	.10	.06	.12
12. Partner frustration at self	-.31 <sup>a</sup>	.07	-.19	-.33 <sup>a</sup>	-.18	-.17	-.01	-.06	.20

*Note.* Matt = mutual attention; Wpos = worker positivity; Ipos = instructor positivity; Crd = coordination; Wrsp = worker responsibility; Irsp = instructor responsibility; Wenj = worker enjoyment; Ienj = instructor enjoyment; Wfrus = worker frustration; Ifrus = instructor frustration; Wnrsv = worker nervousness; Inrv = instructor nervousness; Wexp = worker expressivity; Iexp = instructor expressivity; Wbck = worker back-channel responses; Ibck = instructor back-channel responses; Iadpt = instructor adaptors; Iqual = quality of instructions; Igest = instructor gestures; Rlean = instructor rear lean; Flean = instructor forward lean; Prox = Proximity. Scores for coder-rated behaviors are based on third-party coders' observations of six 20 s "thin slices" (N. Ambady & R. Rosenthal, 1992) of videotapes of participants. Scores for dyadic experience variables are based on participant self-ratings.

<sup>a</sup>Not significant ( $p < .10$ ).

\* $p < .05$ .

within the previously established range,  $r(30) = .25$ ,  $p = .12$ . Thus, it appears that our study did not elicit improved interactant agreement. However, given the consistency of the size of the correlation between interactants' agreement about rapport across multiple studies (cf. Bernieri & Gillis), this correlation probably reflects low agreement rather than no agreement.

Given that rapport agreement was low, comparisons to other constructs may suggest that one should generally expect low agreement between members of dyads. However, interactants did agree about other experiences, such as various types of frustration (see Table 5) as well as partner enjoyment,  $r(29) = .59$ ,  $p < .01$ . Thus, it was not that agreement was difficult to achieve in this study but, rather, that agreement about rapport (among other measured constructs) was difficult to achieve.

Coder-rated behaviors												
Ifrus	Wnrv	Inrv	Wexp	Iexp	Wbck	Ibck	Iadpt	Iqual	Igest	Rlean	Flean	Prox
.07	.12	-.16	.18	.11	.26	-.12	.06	.33 <sup>a</sup>	.08	-.07	-.05	-.10
-.15	-.04	-.01	-.14	-.01	.20	.02	.19	.14	.02	.15	.08	-.07
-.06	.10	-.01	-.22	-.07	.25	.13	-.14	.26	-.28	-.26	.14	.13
-.25	-.07	.17	-.20	-.11	.30	-.05	-.17	.37 <sup>*</sup>	-.06	-.06	.03	.21
.12	.13	-.03	-.04	-.02	.09	.01	-.36 <sup>*</sup>	-.14	.02	.10	-.12	.10
.21	.31 <sup>a</sup>	.31 <sup>a</sup>	-.05	-.02	.00	-.17	-.19	-.20	.01	.06	-.08	.16
.02	.11	-.18	-.03	-.01	.33 <sup>a</sup>	-.04	-.23	.28	-.09	-.12	.11	.02
-.18	.14	-.17	-.18	-.18	.13	-.07	-.16	.25	-.08	.03	.06	-.01
.36 <sup>*</sup>	-.01	-.05	.30	.27	-.27	-.10	.04	-.24	-.11	.02	.13	-.11
.21	.04	.07	.12	.11	-.28	-.24	-.03	-.26	-.00	.10	-.02	-.08
.12	-.08	-.18	.16	.11	-.17	-.20	.04	-.11	.13	.27	-.16	-.01
.27	.22	.15	.16	.11	-.30	-.15	.12	-.33 <sup>a</sup>	.01	.29	-.04	.07

## Discussion

Our primary goal in this study was to examine the behavioral and perceptual correlates of rapport in a context in which both interactants were required to contribute to the task. To create this experience, we artificially limited each partner's contributions: The worker could not see, and the instructor could not physically complete the task. We found that the Tickle-Degnen and Rosenthal (1990) theoretical model of rapport accurately described interactants' reported rapport. We also found that dyadic rapport was related to more constructs from the instructor's than the worker's perspective. In addition to the dyadic experiences, behaviors displayed in the task, but not performance, predicted dyadic rapport. Finally, dyadic rapport agreement did not increase with this task, although dyads did agree on other constructs that were measured.

**TABLE 4. Correlations Between Coder-Rated Sampled Behaviors and Worker Self-Ratings of Dyadic Experience Variables**

Dyadic experience variable	Coder-rated behaviors								
	Matt	Wpos	Ipos	Crđ	Wrsp	Irsp	Wenj	Ienj	Wfrus
1. Mutual attention	.28	.30	.23	.14	.08	.30	.22	.23	-.10
2. Positivity	.04	.16	.30	.05	-.12	.08	.05	.07	-.15
3. Coordination	.33 <sup>a</sup>	.05	.24	.43*	.17	.38*	-.17	-.18	-.22
4. Satisfaction	.31 <sup>a</sup>	.30	.09	.27	.36*	.19	.42*	.38*	.33 <sup>a</sup>
5. Self-responsibility	-.25	.04	-.14	-.33 <sup>a</sup>	-.17	-.05	.12	.10	.30
6. Partner responsibility	-.28	-.03	-.21	-.35 <sup>a</sup>	-.06	-.28	-.09	-.12	.01
7. Self-enjoyment	.25	-.32 <sup>a</sup>	-.14	.21	-.09	.26	-.14	-.12	-.01
8. Partner enjoyment	.12	-.06	.10	.14	-.21	.20	-.08	-.05	-.20
9. Frustration at partner	.01	-.28	-.04	-.07	.01	.18	-.18	-.13	.00
10. Frustration at self	-.32 <sup>a</sup>	-.21	-.40*	-.37*	-.29	-.26	-.26	-.30	.30
11. Partner frustration at me	-.14	-.11	-.25	-.22	-.11	.04	-.17	-.18	.05
12. Partner frustration at self	-.16	-.05	-.02	-.18	-.24	-.07	-.08	-.07	-.04

*Note.* Matt = mutual attention; Wpos = worker positivity; Ipos = instructor positivity; Crđ = coordination; Wrsp = worker responsibility; Irsp = instructor responsibility; Wenj = worker enjoyment; Ienj = instructor enjoyment; Wfrus = worker frustration; Ifrus = instructor frustration; Wnrv = worker nervousness; Inrv = instructor nervousness; Wexp = worker expressivity; Iexp = instructor expressivity; Wbck = worker back channel responses; Ibck = instructor back channel responses; Iadpt = instructor adaptors; Iqual = quality of instructions; Igest = instructor gestures; Rlean = instructor rear lean; Flean = instructor forward lean; Prox = Proximity. Scores for coder-rated behaviors were based on third-party coders' observations of six 20 s "thin slices" (N. Ambady & R. Rosenthal, 1992) of videotapes of participants. Scores for dyadic experience variables were based on participant self-ratings.

<sup>a</sup>Not significant ( $p < .10$ ).

\* $p < .05$ .

### *Rapport Factors*

Tickle-Degnen and Rosenthal (1990) predicted that mutual attention, mutual positivity, and coordination contributed to the dyadic rapport experience. We used two separate groups of variables to analyze this theoretical relationship: self-reports and displayed behaviors. The dyads' self-reported experiences were predictive of rapport, as evidenced by the statistically significant results from a regression analysis between the three variables and rapport (although mutual attention was weakly related). Additionally, a rapport construct derived by combining the three theorized rapport components was strongly related to self-reported rapport. The weak relationship with mutual attention could be context specific: Constraining the worker's sight may have limited the dyad's experience of mutual attention in this task, and the requirement that participants work together may have limited naturally occurring mutual attention.

Coder-rated behaviors												
Ifrus	Wnrv	Inrv	Wexp	Iexp	Wbck	Ibck	Iadpt	Iqual	Igest	Rlean	Flean	Prox
-.09	-.08	.08	.03	.10	.21	.16	-.01	.23	.11	-.33 <sup>a</sup>	.34 <sup>a</sup>	-.20
-.23	.02	-.14	-.07	-.02	-.09	-.16	-.11	.10	-.28	-.18	.31 <sup>a</sup>	-.21
-.29	.03	-.48*	-.23	-.26	.43*	.08	.01	.48*	-.01	-.31 <sup>a</sup>	.24	-.32 <sup>a</sup>
.40*	-.06	-.20	.40*	.44*	.35 <sup>a</sup>	.25	.25	.19	.25	-.31 <sup>a</sup>	-.03	-.21
.38*	.36*	.35 <sup>a</sup>	.28	.20	-.30	.07	.08	-.20	.07	.19	-.20	.24
-.16	.11	.09	.17	-.11	.07	-.36*	.04	-.20	-.02	.08	.29	.01
-.02	.08	-.19	-.24	-.22	-.03	.01	-.39*	.33 <sup>a</sup>	-.32 <sup>a</sup>	-.47*	.11	-.06
-.05	.17	.05	-.29	-.23	-.15	.09	-.39*	.18	-.43*	-.36*	.26	-.10
.10	-.06	.26	-.20	-.01	-.33 <sup>a</sup>	-.14	-.07	-.03	-.14	-.23	.21	-.13
.35 <sup>a</sup>	.16	.33 <sup>a</sup>	-.08	-.12	-.29	-.34 <sup>a</sup>	-.15	-.41*	-.20	-.17	.24	-.20
.13	.13	.28	-.12	-.00	-.16	-.40*	-.00	-.18	-.07	-.14	.31	-.21
.01	-.07	.37*	-.20	.04	-.39*	-.07	.07	-.25	.05	-.09	.26	-.31 <sup>a</sup>

An alternative explanation for these findings is that the relationship between the variables was the result of the presentation of the items in the postpuzzle questionnaire, because all four items were adjacent. However, this is not likely the case. Otto and Grahe (2006) used the dyadic puzzle paradigm to evaluate emotion contagion, and they included items from the postpuzzle questionnaire in a different order than in the present investigation, such that none of the rapport items were adjacent. If the effect was due to the nature of the scale, it should have been diminished. In contrast, Otto and Grahe found nearly identical results such that coordination and mutual positivity, but not mutual attention, were predictive of rapport (*adj. R*<sup>2</sup> = .59). Otto and Grahe's results provide further support for the conclusion that dyads in this context perceive rapport to be related to these two constructs.

Whereas self-reported experiences of these factors predicted rapport, coded behaviors displayed during the interaction did not. Although a modest

**TABLE 5. Agreement Between Worker and Instructor Ratings of Experience Variables**

Variable	<i>r</i>
Dyadic variables	
Rapport <sup>a</sup>	.25
Cooperation	-.13
Individual variables	
Satisfaction <sup>b</sup>	.21
Instructor responsibility	-.35
Worker responsibility	.08
Instructor enjoyment	.36*
Worker enjoyment	.59**
Frustration at instructor <sup>c</sup>	.23
Frustration at worker <sup>d</sup>	.42*
Instructor frustration at self	.42*
Worker frustration at self	.65***
Instructor frustration at worker	.39*
Worker frustration at instructor	.18

*Note.* All *rs* are based on *N* = 30 couples. Dyadic variables refer to items for which participants rated how well the two individuals together (rather than any one of the dyadic members) performed; individual variables represent participants' ratings of one dyadic member's experiences. Correlations for all individual variables except satisfaction were calculated by comparing one dyadic member's self-ratings with the other member's partner-ratings (e.g., instructor enjoyment = instructor rating of self-enjoyment vs. worker rating of partner enjoyment).

<sup>a</sup>Rapport was calculated by averaging ratings for mutual positivity, mutual attention, and coordination. <sup>b</sup>Satisfaction represents each participant's personal satisfaction with how well the dyad performed. <sup>c</sup>Instructor rating of "Frustration at self" vs. worker rating of "Frustration at partner." <sup>d</sup>Instructor rating of "Frustration at partner" vs. worker rating of "Frustration at self." \**p* < .05. \*\**p* < .01. \*\*\**p* < .001.

relationship emerged between dyadic rapport and two of the factors (coordination and instructor positivity), the three factors together did not yield a reliable regression equation. Two plausible explanations emerge for the mixed support for the three-factor model of rapport. First, the results may reflect that the model is context specific and that it is less predictive in this context than in the clinical setting in which Tickle-Degnen and Rosenthal (1990) conducted their study. Coded mutual attention was not reliably related to dyadic rapport, and worker positivity was a negative predictor of rapport. It is possible that rapport in the puzzle task was not enhanced by these factors. As mentioned previously, because the task required the focus of both interactants, mutual attention became less crucial to the dyadic experience. Furthermore, the coded behaviors most strongly related to rapport were those associated with the instructor's effectiveness and disposition. As such, the worker's affective displays may have been less critical to the experienced rapport.

Second, the results may reflect the divergence between the dyads' active perceptions of experiencing the interaction and the coders' passive perceptions of viewing the interactions. The fact that active and passive perceptions of an interaction lead to different mental experiences has been argued repeatedly (Kenny & Albright, 1987; Swann, 1984), and the correlations we found between the dyadic experience variables and coded behaviors support such an explanation. Few of the coded behaviors were directly related to the dyadic experience variable of the same name, even though the relationships that emerged were meaningful. Arguably, both groups had some perceptual advantages. The dyads experienced the complete interaction, whereas the coders experienced only 90 s of the interaction. In contrast, the coders' perceptions were more objective because the coders were not directly involved in the interaction and they viewed multiple interactions. It is precisely this discrepancy that has encouraged researchers to seek results from both perspectives (Funder, 1999; Kenny, 1994).

#### *Ecology of Rapport in Puzzle Context*

The second category of questions examined the manifestation of dyadic rapport in the study context, which we measured using both interactant self-reports and other behaviors in the interaction. These sets of variables suggest that the instructor's behaviors were critical for a dyad to experience rapport. The interactant self-reports of their experiences indicate that dyads with instructors who reported less frustration and more enjoyment, and dyads with workers who assumed less responsibility, experienced more rapport. Our analysis of the displayed behaviors indicates that better communication and more involved instructors predicted rapport. Specifically, dyads with instructors who leaned forward and gave better instructions reported increased rapport. Therefore dyadic rapport was both manifested and measured in this interaction.

Together, these results suggested that rapport emerged from interactions in which both members of the dyad were involved and coordinated, the instructor was more positive and communicative, and both parties attributed responsibility to the worker rather than the instructor. Although they are not identical to the Tickle-Degnen and Rosenthal (1990) model of rapport, our results suggest that their factors are present in this ecology. In addition to coordination and instructor positivity, behaviors that may indicate mutual attention, such as instructor forward lean, were indicative of increased dyadic rapport. Finally, a novel factor, attribution of responsibility, played an important role in dyadic rapport.

When both interactants agreed that the instructor, rather than the worker, was responsible for performance, there was higher rapport. It is important to note that performance itself was not directly related to rapport: Dyads experienced rapport regardless of how successful they were in speed of completion. Rather, it was an understanding of responsibility for performance that influenced rapport. Thus, although the task was designed to require contributions from both parties, it was

one interactant's behavior that both parties valued. This makes sense because even though the interactants needed each other, the instructor possessed the balance of resources to complete the task. Whereas the worker needed to follow instructions effectively to complete the task, the instructor needed to evaluate the situation, choose the appropriate solution, and guide the behavior of the worker. During the experiment, most workers were able to follow instructions; however, not all instructors were able to deliver effective instructions. This finding has particular relevance to the real world, where dyads require mutual contributions but one party is more responsible. For example, in a worker-supervisor scenario, if the supervisor takes little responsibility for the outcome of a task, rapport may suffer. However, if the supervisor takes responsibility for the final outcome, the supervisor and worker may share greater dyadic rapport. This finding regarding responsibility and rapport merits further investigation.

### *Rapport Agreement*

The final issue that we addressed in this study was rapport agreement. Unfortunately, rapport agreement was not greater than in previous studies (Bernieri & Gillis, 2001). However, although the effect was small, it was greater than zero. Otto and Grahe (2006) identified a similar level of agreement when participants were conducting this same task,  $r(31) = .31, p = .09$ . Therefore, constraining roles to force dyadic involvement did not raise interactant agreement about dyadic rapport.

In contrast, dyads did agree about their experiences of other constructs. Reliable relationships emerged for enjoyment, frustration, and responsibility. In these cases, the instructor was more in tune with the worker's experience than vice versa, and not every aspect of frustration was equally communicated. However, these findings reveal that low agreement is not a requirement of dyadic studies. Both enjoyment and frustration are affect laden, as is rapport. However, they are distinct variables. Correlations between these three variables and rapport ranged from .20 to .36, demonstrating that there were multiple constructs being measured.

The nature of the experimental setup may explain why rapport agreement was lower than was agreement on other constructs. The instructor's advantage probably occurred because affective experiences are communicated more effectively through visual channels of communication (e.g., facial expressions and gestures) than through audio (e.g., tone of voice) or verbal (e.g., what is said during the interaction) channels (Depaulo, 1992; Noller, 1985). More specifically, judgments about dyadic rapport are likely most accurate when visual information is available (Grahe & Bernieri, 1999). The constraints on the worker effectively limited the most informative channel of communication about affect and rapport. Furthermore, given that rapport is inherently dyadic, the inability of the worker to see the instructor's behaviors probably limited the worker's ability to perceive the instructor's experience of rapport. Perhaps the dyadic nature of the task did increase agreement, but our limiting the worker's perceptual abilities diminished this increase.

### *Limitations and Future Directions*

Although this study yielded intriguing results, there were some limitations. First, the sample size of the study was not optimal. Although it was the onerous coding demands of the study that limited the number of dyads that could reasonably be examined, the study also lacked power. Additionally, because of the number of coded variables in the study, we computed the stepwise regressions with low sample-size-to-predictor ratios; thus, some of the present findings may be due to Type I errors (Stevens, 1992). However, because our procedure produced results that accord with previous research findings, this is not likely the case. Therefore, although skepticism about the reliability of our results is warranted, these findings should be tested in follow-up studies rather than ignored because of a limited sample size.

Another limitation of this study may be the task itself. The constraints on participants forced mutual contributions, but these constraints may have prevented the interactants from engaging in important communication about their feelings. Furthermore, it was difficult to design an adequate control condition because having 2 participants complete children's puzzles when both could see would have led to a quantitatively and qualitatively different experience. Thus, future researchers should compare a task with mutual contributions to a task with uneven contributions to better understand the manifestation of rapport. For example, a dyad working together on a computer where one interactant controls the mouse while the other controls the keyboard may allow the dyadic members to experience mutuality without sacrificing visual, nonverbal communication.

### *Conclusion*

Our results support previous research findings that the rapport experience arises from a combination of dyadic variables, but that participants do not fully agree about their rapport experiences. Furthermore, participants' awareness of each other's feelings of frustration and enjoyment suggests that disagreement about rapport is a distinct phenomenon and is not related to an inability to interpret their partners' experiences. Finally, we found that the context of the situation impacts the manifestation of rapport-defining behaviors, as previous researchers have suggested (Bernieri et al., 1996; Puccinelli et al., 2003; Slotnik, 1996).

### NOTES

1. Although some dyads completed only two puzzles, we retained an  $N = 30$  (dyads) using the average of the two puzzles rather than three. This introduces an extra element of error variance and should thus make estimates slightly conservative.

2. To conserve space, in the present article we do not report results regarding the relationship between the three puzzles or between the 2nd and 2nd-to-last min samples. Further data from these analyses can be obtained from Jon E. Grahe.

## AUTHOR NOTES

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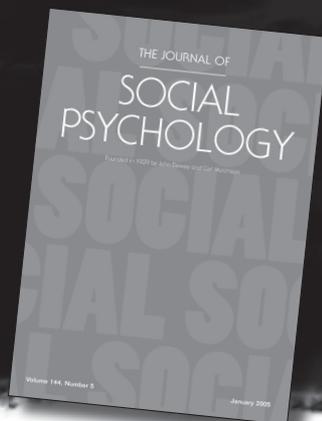
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