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Marital Interaction: Physiological Linkage and Affective Exchange

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Thirty married couples were studied during naturalistic interactions to determine the extent to which variation in marital satisfaction could be accounted for by physiological and affective patterns between and within spouses. The authors hypothesized that (a) compared to nondistressed couples' interactions, distressed couples' interactions would show greater physiological interrelatedness or "linkage," more negative affect, and more reciprocity of negative affect and (b) these differences would be more pronounced when the interaction was high in conflict (discussing a marital problem) as opposed to low in conflict (discussing the events of the day). Heart rate, skin conductance, pulse transmission time, and somatic activity from both spouses were analyzed using bivariate time-series techniques to derive a measure of physiological linkage. Self-report affective data (obtained using a video-recall procedure) were analyzed using sequential analyses to derive a measure of affect reciprocity. The hypotheses were strongly supported; 60% of the variance in marital satisfaction was accounted for using measures of physiological linkage alone. Additional nonredundant variance was accounted for by the other physiological and affective measures.

Social interaction provides a rich, naturalistic, and theoretically advantageous context for studying the relations among physiological, affective, and behavioral phenomena. Unfortunately, the demands associated with laboratory experimentation extract significant compromises that may escalate until the experimental context bears little relation to natural dyadic interaction. For example, interaction between two strangers may be substituted for interaction between intimates; a carefully "programmed" confederate may replace the second person; and finally, the confederate may be replaced by a film, a photograph, an audio recording, or a situation created in the subject's own imagery. In this experiment, naturalistic interaction within a husband–wife dyad was used as the context for studying physiological and affective responses. We expected that physiological and affective patterns within these dyads would reflect both the level of marital satisfaction and the extent of conflict in the interaction.

Affective Patterns in Distressed, Dissatisfied Marriages

Interactions between spouses in distressed and nondistressed marriages have been consistently found to differ in terms of affective patterns. Birchler, Weiss, and Vincent (1975) observed greater negative affect (during problem solving and conversation) and less positive affect (during problem solving) in distressed couples. Similarly, there have been several reports of more humor, more laughter, more support, and less defensiveness in nondistressed than in distressed families (Mishler & Waxler, 1968; Riskin & Faunce, 1970). Gottman (1979) proposed a model in which marital satisfaction is related to three dimensions: (a) positive–negative affect, (b) negative-affect reciprocity (i.e., patterned exchanges of negative affect between the husband and wife), and (c) asymmetry. He hypothesized that interaction in dissatisfied marriages would be characterized by less pos-

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itive affect, more negative affect, more reciprocity of negative affect, and greater asymmetry of predictability of affect (i.e., one spouse would dominate the exchange of affect) than in satisfied marriages. Research supporting this model has been reported in independent laboratories in the United States (Gottman, 1979, 1980; Margolin & Wampold, 1981), Germany (Revenstorf, Vogel, Wegener, Halweg, & Schindler, 1980), and the Netherlands (Schaap, 1982).

We hypothesized that the patterns of observable affect and affect exchange that typify dissatisfied marriages would be accompanied by parallel patterns in physiological response. Because negative emotions are intimately associated with physiological activation (e.g., the sympathetic nervous system activity associated with fear and anger), we hypothesized that patterned exchanges of negative affect within the dyad would activate physiological systems and produce parallel patterning of physiological responses between the spouses. We found no research on marital interaction that provided evidence directly relevant to this point but did find several studies of dyadic interaction that included physiological measurement and provided some support for this hypothesized relation between negative affect and physiological linkage.

Interpersonal Psychophysiology

There is limited, but consistent, evidence that physiological responses between members of an interacting dyad can show considerable relatedness or linkage. In the 1950s several studies were reported of the physiological responses of psychotherapists and their clients during interviews. DiMascio, Boyd, Greenblatt, and Solomon (1955) reported that heart rates of the therapist and a neurotic patient undergoing long-term psychotherapy "often varied together and at other times varied inversely from each other other" (p. 9). DiMascio, Boyd, and Greenblatt (1957), using the first 12 interviews with a patient in therapy, found that the therapist's and patient's heart rates moved in similar directions as the levels of "tension" in the interview varied but moved in opposite directions when the patient expressed "antagonism" toward the therapist. In a study of the effects of an examiner's praise or criticism of female neurotic patients' responses to a diagnostic test, Malmo, Boag, and Smith (1957) found that the amplitude of the electromyogram (EMG) obtained from the chin of the examiner and the patient both fell following praise and remained constant following criticism. In Kaplan and Bloom's (1960) review of this literature, they interpreted these results as indicating a physiological component of "empathy." This theme was restated by Ax (1964) when he speculated that empathy might be thought of "as an autonomic nervous system state which tends to simulate that of another person" (p. 12).

More recently, Kaplan, Burch, and Bloom (1964) reported two studies of correlations in skin conductance among dyads constituted on the basis of sociometrically determined "liking" and "disliking." In the first study, using male subjects, one four-person group in which all subjects disliked each other, a second four-person group in which all subjects liked each other, and a third four-person group comprising a mixture of liking and disliking were studied during five 45-minute discussion sessions. The data were analyzed in terms of two-person dyads. Results indicated that dyads from the group that disliked each other were more likely to show significant correlations in skin conductance compared to the other two groups. In the second study, female subjects interacting in dyads (10 liking, 10 disliking, and 10 neutral dyads) in two 20-minute discussion sessions were used. Again, subjects paired on the basis of mutual dislike were most likely to show significant correlations in skin conductance.

Methodological Problems

We felt that the results from the studies of interpersonal psychophysiology were encouraging but not without problems. First, in many of these studies an attempt was made to characterize the physiological relation in a dyad on the basis of a single autonomic nervous system (ANS) measure; a more broadly based set of physiological measures would provide a better test of this relation. Second, it is important to determine whether the physiological relation in a dyad provides information beyond that which is provided by other measures, such as simple self-report measures. Although it would certainly be interesting to find that physiological measures provide essentially the same information as self-report measures, the additional expense and obtrusiveness of physiological measures would hardly be justified unless they provided additional, nonredundant information. Third, the use of running correlations to assess physiological relatedness between members of a dyad has serious problems. Because these kinds of observations are not independent, the significance tests of the correlation are incorrect; errors of nearly 500% have been found in such instances by Hibbs (1977). Further, *within* each member's data there are autocorrelations (i.e., cyclicity) that must be controlled for before inferences regarding correlational relations *across* subjects can be drawn. This is particularly important in studies in which the manipulation (or dyadic grouping) could be expected to increase the autocorrelation within each subject's data (see Gottman, 1981; Gottman & Ringland, 1981).

The present study addressed these problems by including multiple physiological measures, including a procedure that obtained self-report affective measures continuously without interrupting the flow of behavior, employed more appropriate time-series analytic techniques for determining the degree of physiological relatedness *across* subjects, and determined the extent of nonredundancy between physiological and affective measures.

Four primary hypotheses were tested. First, as indicated earlier, we hypothesized that physiological linkage would occur in situations in which negative affect was prevalent and in which this affect was exchanged or reciprocated between members of the interacting dyad. Second, we hypothesized that physiological linkage would be greater when dyads were engaged in a high-conflict interaction that would elicit more negative affect, such as discussing marital problems, compared to a relatively low-conflict interaction, such as discussing the events of the day. Third, we hypothesized that physiological linkage would be negatively correlated with marital satisfaction, because interactions among spouses in dissatisfied marriages would be more likely to manifest negative affect and negative-affect reciprocity. Finally, we hypothesized that the information obtained from studying patterns of physiological activity would provide information that was nonredundant with that which could be obtained by simply studying affective patterns.

Method

Subjects

Married couples were recruited using two brief advertisements placed in the Bloomington, Indiana, newspaper. To obtain a representative sampling of marital-satisfaction levels, the first advertisement asked for "couples needed for research project studying marriage," whereas the second asked for "couples having difficulty solving marital problems." The approximately 100 respondents to the advertisements were further screened on the telephone to ensure that English was their native language and that they could meet our scheduling requirements. In this initial telephone contact, the subjects were told that the experiment would involve coming to the laboratory to discuss neutral topics and problem areas in their marriage and that videotape, self-report, and physiological data would be obtained. The first 30 acceptable couples formed the subject sample used in the experiment. Each couple was paid $30 for 4 hours of participation.

Apparatus

Physiological data. The selection of physiological variables represented a compromise between two opposing considerations: our desire to constrain and encumber subjects as little as possible and our desire to obtain as comprehensive a physiological assessment as possible within the technical limits imposed by simultaneously recording data from two subjects. These considerations led us to select four physiological dependent measures obtained from three kinds of recording devices placed on the surface of the subject's skin and from a fourth device attached to the subject's chair. On-line analysis of the physiological data was accomplished using a system consisting of an eight-channel Grass Model 7 polygraph and a PDP 11/10 minicomputer, which was equipped with analog-to-digital capabilities and was programmed to process the following measures from each subject continuously and to average the measures into 10-sec measurement periods:

Heart rate measured by the interbeat interval (IBI). Beckman miniature electrodes with Redux paste were placed in a bipolar configuration on opposite sides of the subject's chest. The time interval between successive R waves on the electrocardiogram was measured at a resolution of 1 msec. IBI was included because it is an ANS function that can be altered by both sympathetic and parasympathetic influences and because changes in rate of contraction are one of the basic ways by which the heart regulates its output of blood to the body.

Pulse transmission time to the finger (PTT). PTT was determined by measuring the time interval between the R wave and the arrival of the pulse pressure wave at the middle finger of the nondominant hand. A Grass PTT photoplethysmograph was used to detect the pulse wave, and the resolution was 1 msec. PTT was included because it reflects different cardiovascular activities than IBI (i.e., changes in the force of the heart's contraction and changes in the distensibility of the arteries between the heart and the finger, both mediated primarily by the sympathetic branch of the ANS). Changes in contractile force are the other basic method (besides heart rate) by which the heart regulates its output.

Skin conductance level (SCL). A constant-voltage device was used to pass a small voltage between Beckman regular electrodes attached to the middle phalanges of the first and third fingers of the nondominant hand. The electrolyte was Beckman electrode paste. SCL recorded from this site was included because it measures the activity of sweat glands thought to be related to emotionality. It is under the control of the sympathetic branch of the ANS but has a different stimulation chemistry than does the sympathetic cardiovascular functions involved in IBI and PTT.

General somatic activity (ACT). An electromechanical transducer attached to the platform under each subject's chair detected movement in any plane. This totally unobtrusive measured provided a global index of somatic muscle activity.

These four measures provide a reasonable breadth of measurement because they reflect the activity of four physiological systems (heart, vasculature, sweat glands, muscles). In addition, IBI, PTT, and SCL are all sensitive to sympathetic nervous system activity, which has an evolutionary connection with negative emotions, such as fear and anger, by virtue of its role in preparing the organism for the adaptations of "fight" and "flight."

Self-rating of affect. A simple positive/negative affective measure was used in keeping with our experience that individuals who are inexperienced in rating their own affect find more complex affective measures too difficult. Empirical evidence (e.g., Osgood, Suci, & Tannenbaum, 1957) indicates that the positive/negative dimension accounts for most of the variance in emotional judgments. Furthermore, we wanted to obtain a continuous report of affect (as opposed to discrete pretest and posttest measures) that reflected the moment-to-moment affective changes during interactions. To accomplish this, the husband and wife returned to the lab in separate sessions to view the videotape of their interaction and to provide affect ratings (see procedures below). The ratings were obtained by having the subject manipulate a dial whose pointer moved on a 180° scale divided into nine divisions, with the legends "very negative" at 0°, "neutral" at 90° (this was at the center of the fifth division), and "very positive" at 180°. The dial was attached to a potentiometer in a voltage-dividing circuit that was monitored by the computer to enable determination of the dial position. The subject was asked to adjust the dial position as often as necessary while viewing the videotape so that it always reflected the way he or she felt during the initial interaction session. The computer sampled the dial position every 5 msec and averaged these readings into 10-second measurement periods.

Video data. During the interaction session (see below), the spouses were seated facing each other in two comfortable chairs in the center of a small room. Two monochrome video cameras and two electret microphones were mounted on shelves on the wall opposite each chair and slightly above head level. The video signals from the two cameras were combined into a split-screen image using a video mixer and then routed to a time-code generator that superimposed the elasped time at a resolution of 10 msec. The audio signals from the two microphones were combined using an audio mixer. The resultant video and audio signals were recorded on a reel-to-reel video recorder. All mixing and recording equipment were located in the room adjacent to the subject room, which also contained the physiological-data recording equipment.

Synchronization of physiological, affective, and video data. To enable synchronization between these three data sources, it was necessary to establish a common "time zero." This was accomplished in the interaction session by having the computer remotely start the video time-code generator at the same moment that it started timing the physiological and affective data. In the video-recall session (see below), subjects viewed this videotape while a new set of video, affective, and physiological data was obtained. To synchronize these new data with the data from the interaction session, a strip of reflective foil was placed on the back side of the videotape of the interaction session at the point at which the video time code was started. A locally constructed optoelectric device was used to detect this foil strip and send a signal to the computer, which then started the time-code generator for the new video recording and started the new physiological and affective data recording. In this manner the same time zero was established for all data sets.

Procedure

Interaction session. To ensure that sufficient interaction would occur, couples were scheduled for the initial laboratory session at a time when they would not have interacted with each other for 8 hours. For most couples this meant scheduling the session in the early evening hours after work. When the subjects arrived the female experimenter (an advanced doctoral student in clinical psychology) provided them with an overview of the procedure, asking them to interact as naturally as possible and to avoid trying to effect any particular kind of behavior. In particular, they were asked to speak to each other rather than to the cameras and not to worry about explaining events or identifying names for our benefit. A female technician entered the room and attached the physiological recording devices to the wife, explaining the function of each device. Then the recording devices were attached to the husband. After verifying the quality of all physiological signals, the experimenter returned to present the instructions for the first interaction segment.

The first segment began with a 5-minute period of silence that served as a preinteraction baseline. After 5 minutes, a small amber light on a table beside them was illuminated, indicating that the conversation should begin. The couple was asked to engage in their typical conversation about the events of the day as if they were home alone at day's end and to continue the conversation until the amber light was extinguished (after 15 minutes of conversation). The experimenter left the room, the video recording was started, and the computer started the time-code generator, beginning the 20 minutes of physiological data collection.

The experimenter returned to the room after the first segment to administer a series of four questionnaires that each spouse completed separately over a 20-minute period. The questionnaires included a demographic measure, a problem inventory in which they rated the severity of a number of common marital problems, and two inventories of marital satisfaction (Burgess, Locke, & Thomes, 1971; Locke & Wallace, 1959).[1]

The experimenter examined the couple's answers to the problem inventory and selected a problem area that both spouses rated as being important. This problem was discussed with them to attempt to focus the conflict on a single issue, to elicit their feelings about the conflict, and to determine whether the problem was a source of continuing conflict for them. If the issue had already been resolved, if the conflict was too diffuse to focus on a single issue, or if the couple felt extremely uncomfortable discussing the topic, then this procedure was repeated for another high-priority topic until an acceptable topic had been identified.

After the experimenter left the room, the second interaction segment began with a 5-minute silent baseline. The couple was signaled by the amber light to begin discussing the problem area in an attempt to reach some solution or compromise. Video and physiological data were collected in the same manner as in the events-of-the-day segment, and this discussion continued until the amber light was extinguished (after 15 minutes).

The experimenter reentered the room and helped the couple resolve any remaining tension resulting from the previous interaction. The technician then entered and removed the recording devices. Each spouse was then scheduled for a separate video-recall session.

Some mention should be made concerning our decision not to counterbalance the orders of the two interactional segments. Pilot testing revealed that if the problem-area segment came first, then negative affect persisted and contaminated the events-of-the-day segment.

Video-recall sessions. Each spouse returned to the laboratory for a separate session at a convenient time within 3 to 5 days[2] after the interaction session. For this session, a video monitor was placed in the position previously occupied by the spouse's chair. The experimenter provided an overview of the session's procedure, carefully explaining the use of the affect rating dial. Then the technician attached the physiological recording devices to obtain the same set of measures obtained in the original session. A video recording of the spouse viewing the tape of the interaction session was also obtained.

The session consisted of the spouse's viewing the tape of the two 20-minute interaction segments (separated by a 10-minute rest period) from the first session and providing the affect ratings. After the video-recall session for the second spouse, the payment for the entire experiment was made.

Data Analysis

Physiological data. For the purposes of the present report, we worked with the four physiological measures (IBI, PTT, SCL, ACT) obtained in the interaction session.[3] Each dependent variable was averaged into 10-sec periods for the husband and wife during the events-of-the-day and problem-area interactions. Each of these in-

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[1] These measures of marital satisfaction have a venerable 40-year history, beginning with the work of Terman, Buttenwieser, Ferguson, Johnson, and Wilson (1938). They have been employed in longitudinal and cross-sectional studies, have been refined over the years, and have been shown to have reasonable levels of construct and predictive validity. Historically, most measures of marital satisfaction have been highly correlated. Burgess and Wallin (1953) suggested that the various constructs used by researchers to assess people's attitudes toward their marriages were tapping one basic dimension; this conclusion has held up. Every few years a new measure of marital satisfaction is proposed (e.g., Spanier, 1976), but it invariably correlates very highly with the older measures (i.e., Burgess, Locke, & Thomes, 1971; Locke & Wallace, 1959) that we used.

[2] The decision to have subjects return to the laboratory for a separate recall session meant introducing an unwelcome time lapse between obtaining the physiological and affective data sets; this could introduce error that would work against our hypotheses. Several considerations went into this decision. We did not want to impede the natural course of the interaction by having subjects adjust the affect rating dials during the interactions. We considered having subjects view the tapes immediately following the interaction, but this would have made for an extremely long and arduous session, and the resultant irritation would undoubtedly distort the affect ratings. Despite the fact that subjects reported no difficulty recapturing their affective experience when watching the video tape, we cannot definitively assert that the ratings obtained after this delay are as accurate as ratings that might have been obtained sooner. Pertinent to this question are the results of some recently completed preliminary analyses of the relation between subjects' physiological responses during the interaction session and during the video-recall session. Thus far we have found these physiological data to be highly related; for example, a statistical measure of the coherence between the husband's skin conductance level data in the two sessions was significant for 56 of the 60 interaction segments (events of the day and problem area for each of the 30 husbands). This indicates that subjects may "relive" the original experience physiologically when viewing the videotape of the interaction. An even more relevant test will be made when our coding of the affective content of the interaction section is completed; we expect these "objective" ratings to confirm the subjects' self-ratings reported here.

[3] Currently in progress are analyses of the physiological data collected during the video-recall sessions and detailed coding of the behavioral and affective data in the video records. These results will be reported at a later date.

teractions consisted of a 5-minute "baseline" (thirty 10-sec periods) and 15 minutes of interaction (ninety 10-sec periods). Thus, the total physiological data set consisted of 57,600 data points (30 couples × 2 spouses × 2 interaction segments × 4 dependent variables × 120 periods). We computed the average of the husband's and the wife's scores on the two marital-satisfaction inventories administered in the interaction session to derive an overall measure of marital satisfaction (M = 111.7, SD = 21.8).

For the traditional and time-series analyses we planned, several preliminary data reductions were needed. First, simple summary statistics (means and standard deviations) were calculated for each dependent measure for each spouse for the following segments: (a) baseline prior to events of the day, (b) events of the day, (c) baseline prior to problem area, and (d) problem area. Then the four dependent measures from each subject for each 15-minute interaction segment were normalized by computing z scores for the ninety 10-sec periods using the mean and standard deviation from the 5-minute baseline that preceded that segment.

The normalized data were used in bivariate time-series analyses to determine the extent of each couple's physiological linkage using the four physiological measures obtained from a husband and wife during a given interaction segment. The interested reader is referred to Gottman (1981, chapters 23–25) for a complete description of these techniques and their mathematical basis. Because some readers may not be familiar with time-series analysis, a brief example will be provided using a husband's and a wife's IBI. The time-series analyses provided us with two chi-square values. One represents the extent to which the husband's pattern of IBI accounts for variance in the wife's pattern of IBI *beyond* the variance accounted for by her own pattern of IBI (thus controlling for the autocorrelation problem mentioned earlier). The second represents the extent to which the wife's pattern of IBI accounts for variance in the husband's pattern of IBI *beyond* the variance accounted for by his own pattern of IBI. These chi-square values were converted to z scores to enable comparison across measures (these z scores can also be used to test significance). In a similar manner, a pair of z scores was computed for each of the remaining three physiological variables (PTT, SCL, and ACT). The resulting set of eight z scores were used to determine the extent of the "multivariate" physiological linkage between a couple during that interaction segment.

Self-report of affect. Simple summary statistics and normalized scores were computed in the same way that was used for the physiological data. We also needed to derive an affective measure that would reflect "reciprocity of affect." On an a priori basis, criteria were established for determining whether each spouse's self-reported affect in each of the ninety 10-sec periods was positive, negative, or neutral. To be coded positive, the raw score average had to be greater than or equal to 6.0 (referenced to the original 9-point affect-rating dial scales), and the z score had to be greater than or equal to .5. Thus, a positive code meant that the pointer was actually on the positive portion (the raw score criterion) of the dial *and* was positive relative to the subject's range of ratings (the z score criterion). To be coded negative, the raw score average had to be less than or equal to 4.0 *and* the z score had to be less than or equal to −.5. The number of 10-sec periods during the interaction that were coded positive and negative for the husband (HPOS, HNEG) and the wife (WPOS, WNEG) provided a measure of the amount of each kind of affect for each spouse.

Affect-reciprocity scores were derived for positive and negative affect at lag zero and at a lag of one 10-sec measurement period. The computations for positive affect reciprocity used the following data: (a) HPOS—number of 10-sec periods in which the husband's affect rating was coded positive; (b) WPOS—number of periods in which the wife's affect rating was coded positive; (c) HWPOSO (and WHPOSO)—number of periods in which *both* the husband's and the wife's affect ratings were coded positive; (d) HWPOS1—number of periods in which the husband's affect rating was coded positive and the wife's affect rating was coded positive in the *following* period; and (e) WHPOS1—number of periods in which the wife's affect rating was coded positive and the husband's affect rating was coded positive in the *following* period.

Recalling that there were ninety 10-sec periods during both the events of the day and problem-area interaction segments, the four z-score[4] positive affect-reciprocity scores for each segment were computed as follows:

At lag zero, wife reciprocates husband's affect =

$$\frac{(\text{HWPOS}/\text{HPOS}) - (\text{HPOS}/90)}{\sqrt{\dfrac{(\text{HPOS}/90) \times [1 - (\text{HPOS}/90)]}{\text{HWPOS}}}}.$$

At lag zero, husband reciprocates wife's affect =

$$\frac{(\text{WHPOS}/\text{WPOS}) - (\text{WPOS}/90)}{\sqrt{\dfrac{(\text{WPOS}/90) \times [1 - (\text{WPOS}/90)]}{\text{WHPOS}}}}.$$

At lag of one period, wife reciprocates husband's affect =

$$\frac{(\text{HWPOS1}/\text{HPOS}) - (\text{HPOS}/90)}{\sqrt{\dfrac{(\text{HPOS}/90) \times [1 - (\text{HPOS}/90)]}{\text{HWPOS1}}}}.$$

At lag of one period, husband reciprocates wife's affect =

$$\frac{(\text{WHPOS1}/\text{WPOS}) - (\text{WPOS}/90)}{\sqrt{\dfrac{(\text{WPOS}/90) \times [1 - (\text{WPOS}/90)]}{\text{WHPOS1}}}}.$$

The z-score negative-affect-reciprocity scores were computed in a similar manner. The rationale behind these computational formulas was to provide measures of reciprocity that were corrected for the total number of periods meeting our positive- and negative-coding criteria. Thus, these reciprocity scores can be thought of as indicating the gain in prediction of one spouse's affect by knowledge of the partner's affect.

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[4] These z scores for lags zero and one are more conservative than those proposed by Allison and Liker (1982).

Results[5]

Affect Ratings During Interaction Segments

We chose the topics for the two interaction segments in hope of obtaining two different levels of negative affect, and the affect-rating data indicated that we were successful. The couples' average rating for the problem area segment was 3.8 (referenced to the 9-point scale), which was significantly more negative than the 4.4 average rating for the events-of-the-day segment, $t(29) = -6.25$. Within the segments, there was no difference between the husband's and the wife's ratings for the events-of-the-day segment, $t(29) = .14$, but the wife's ratings were more negative than the husband's during the problem-area segment, $t(29) = -2.23$.

Physiological Linkage and Marital Satisfaction

We hypothesized that physiological linkage would be negatively related to marital satisfaction and that this relation would be more pronounced in a high-conflict situation. These hypotheses were tested in several stages using each interaction segment's set of eight bivariate time-series z scores (as indicated earlier, these represented the predictability, controlling for autocorrelation, from husband to wife and from wife to husband for the four physiological dependent measures). To determine the overall direction of the relation between physiological linkage and marital satisfaction, it was necessary to derive a single index of physiological linkage; a simple average of the eight bivariate z scores from each segment provided this index. Pearson product-moment correlations revealed that this index was not significantly correlated with our measure of marital satisfaction for the events-of-the-day segment ($r = -.04$), but the correlation was significant for the problem-area segment ($r = -.31$). Thus, during the problem-area segment, greater physiological linkage was associated with lower marital satisfaction. To assess the strength of this relation, a hierarchical multiple regression analysis was used to determine the multiple correlation between marital satisfaction and each interaction segment's entire set of eight bivariate z scores. This analysis revealed a nonsignificant correlation during the events of the day ($R = .44$), $F(8, 21) = .63$, but a significant correlation during the problem area ($R = .77$), $F(8, 21) = 3.93$. Thus, our measures of physiological linkage during the problem-area segment were able to account for 60% of the variance in marital satisfaction.

The pattern of significant correlations supported our hypothesis that physiological linkage was stronger in the high-conflict problem-area segment than in the low-conflict events-of-the-day segment. To verify this, a Fisher's z test of the two multiple correlations indicated that the correlation during the problem-area segment was significantly stronger than the correlation during the events of the day ($z = 2.15$).

Affect and Affect Reciprocity During Marital Interaction

Using the average of both spouses' scores on the two marital-satisfaction inventories as a measure of marital satisfaction, we correlated this average with our "amount of affect" scores (i.e., WPOS, WNEG, HPOS, and HNEG) and affect-reciprocity z scores. During the events-of-the-day segment, wives in dissatisfied marriages reported more negative affect ($r = -.45$), but there were no differences in husbands' affect or in affect reciprocity. During the problem-area segment, wives in dissatisfied marriages reported less positive affect ($r = .33$). For dissatisfied marriages there was more reciprocity of negative affect at lag zero ($r = -.32$), more of the wife's reciprocating the husband's negative affect at lag one ($r = -.41$), and less of the husband's reciprocating the wife's positive affect at lag one ($r = .31$). To this point, the pattern that emerged was consistent with what we expected, with dissatisfied marriages showing poverty of positive affect and abundance of negative affect and negative-affect reciproc-

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[5] Unless otherwise stated, the .05 significance level was adopted, and significance tests of Pearson product-moment correlations were performed using 28 degrees of freedom.

ity. However, dissatisfied marriages had more of the wife's reciprocating the husband's positive affect at lag zero ($r = -.31$) and at lag one ($r = -.31$).

Our hypothesis that the physiological linkage and affect measures would provide additional nonredundant information about marital satisfaction was tested for the problem-area segment in three ways. First, there were no significant univariate correlations between our simple index of physiological linkage (i.e., averaged z scores) and any of the five affect and affect-reciprocity scores reported above to be correlated with marital satisfaction. Second, a hierarchical multiple regression analysis indicated that adding this set of five affect and affect-reciprocity measures to the set of eight physiological bivariate z-score measures significantly increased (by 16%) the variance acounted for, $F(13, 16) = 3.81$ ($R = .87$). Then a canonical correlation between the two sets of measures revealed nonsignificant correlations between the canonical variables. Thus, the physiological linkage and affect measures evidenced considerable independence in their ability to account for variance in marital satisfaction.

Other Physiological Variables and Marital Satisfaction

There were also a number of significant univariate correlations between marital satisfaction and our summary physiological measures (i.e., means and standard deviations for the preinteraction baselines and interaction segments). For distressed couples, the husband had a lower SCL during the baseline prior to the events of the day ($r = .51$), less SCL variability during the interaction ($r = .32$), and the wife had greater PTT variability during the interaction ($r = -.56$). This dyadic pattern could be described as an underaroused, unreactive husband with a very reactive wife, but such description must be considered to be only metaphorical at best. The pattern shifted a bit during the problem-area segment. For distressed couples, the husband again had a lower SCL during the baseline preceding the interaction ($r = .45$), again had lower SCL variability during the interaction ($r = .37$), but now had a faster heart rate (i.e., shorter IBI) during the interaction ($r = .32$).

We found evidence that these summary physiological measures could add additional nonredundant information concerning marital satisfaction to that provided by the physiological linkage and affect measures obtained during the problem-area segment. None of the three physiological summary measures that were significantly correlated with marital satisfaction were significantly correlated with the simple index of physiological linkage. Although the ratio of predictor variables to subjects demands interpretative caution, a final hierarchical multiple regression analysis revealed that adding this set of three summary physiological measures to the sets of physiological linkage and affect measures accounted for significant additional variance (4%) in marital satisfaction, $F(16, 13) = 3.22$ ($R = .89$).

Discussion

When the plan for this experiment was formulated, we were certain of the theoretical advantages inherent in using social interaction to study the role of physiological linkage and affective exchange in marriage but not at all certain of its viability. We wondered whether we could devise a procedure in which married couples would come to the laboratory, be "wired up" for electrophysiological recordings, have video recordings made, and still interact in a manner that would be representative of their interactions at home. We also worried about devising methods for obtaining multiple psychophysiological measures from two subjects at the same time, about how we could obtain affective reports without interrupting the natural interactive sequences, and about how we would make sense of the data in terms of interrelations between the affective and physiological responses produced by two subjects. We now believe that the methods of procedure and analysis that we arrived at are reasonable and valid. As for the natural quality of the interactions, we can state without equivocation that it is our conviction, after viewing the recordings of these sessions many times, that these interactions are typical of marital interaction. Once these couples, separated for at least 8 hours, were put at ease by our assistants, the artifacts of the experiment—the wires, transducers, and cameras—seemed to recede into a very distant background, and their interactions showed the fullest range of caring, anger, sadness, happiness, sensitivity, insensitivity, pedantry, spontaneity, recrimination, and apology that are seen in marital interaction.

In the subjects' own self-ratings of these interactions, we found the same kinds of patterns of affect that others have reported in the literature, namely, less positive affect and more negative affect in dissatisfied marriages, especially when the topic turned to a problem area in the marriage. These findings are predicted by Gottman's (1979) model. By operationalizing measures of affect reciprocity, we were also able to provide support for the model's prediction of greater reciprocity of negative affect in dissatisfied marriages. This took the form of greater reciprocity of the husband's negative affect by the wife at lag zero and at lag one. The model's prediction of greater affective asymmetry in dissatisfied marriages derived some support as well. A picture emerges of the husband being the nonresponsive partner in dissatisfied marriages. Compared to satisfied marriages, he was less likely to reciprocate the wife's positive affect (at lag one in our data). Although there was little positive affect in the interactions of the most dissatisfied couples, consistent with results previously obtained by Gottman (1979), there was greater reciprocity by the wife of the husband's positive affect at lag zero and at lag one.[6]

A similar pattern of results for negative and positive affect and affect reciprocity was obtained by Gottman (1979) for both observational and self-report data of distressed couples in the early lags of sequential analyses of marital interaction. Gottman interpreted these results in terms of information theory; there is more stereotyping, rigidity, or sequential restraint in the affective interactions of dissatisfied couples. Each message thus contains less information than in the less constrained interaction of satisfied couples. Similar results have been obtained for talk–silence patterns in discriminating distressed from nondistressed families (for a review see Gottman, 1979, chapter 3).

It is probably worth repeating the caveat that these affective data are based completely on couples' self-ratings. We have every reason to believe they are veridical because the positive–negative rating dimension was easily managed by our couples, their responses were obtained continuously while viewing the unedited recording of the interaction, and the other spouse was not present when the ratings were made. It should also be noted that, strictly speaking, these are measures of what is felt by subjects and not necessarily what was displayed behaviorally. When our detailed coding of these records is completed, we will be able to compare the fine-grained coding of affective behavior by our "objective" coders with those ratings obtained from the spouses. We expect the results to be quite comparable.

The physiological findings supported our hypothesis of greater physiological linkage in dissatisfied marriages during a high-conflict interaction. In fact, we were able to account for 60% of the variance in marital satisfaction in this sample on the basis of physiological linkage during the discussion of a problem area in the marriage. It is important to note that no previous research has ever accounted for this much variance in marital satisfaction. Questionnaire measures, which have the problem of common method variance, have typically accounted for less than 10% of the variance in marital satisfaction (see Burgess et al., 1971, for a review). The few observational studies that have been done have fared somewhat better, usually accounting for approximately 25% of the variance (e.g., Gottman, 1979). Thus, the present results represent a substantial increase in variance accounted for over previous research.

We believe that physiological linkage oc-

[6] It is interesting to note that reciprocal contracting or quid pro quo therapies for distressed marriages that attempt to increase rates of positive-affect reciprocity (e.g., Lederer & Jackson, 1968) are based on assumed deficits in positive-affect reciprocity that we found for husbands, but not for wives, in this study. In addition, our findings indicate that greater attention should be paid to reducing negative-affect reciprocity in distressed marriages.

curs in the context of negative-affect expression and exchange. Assuming that Kaplan et al.'s (1964) groups and dyads, paired on the basis of mutual dislike, were likely to express and reciprocate more negative affect, then our findings replicate theirs with improved methodology and analyses. Our hypothesis that physiological linkage would tell us something different than affect ratings was also supported. The orthogonality of our physiological linkage measures from affective *and* intraindividual physiological summary measures indicates that they are tapping a different dimension of the interaction than either of these more traditional measures. We believe that physiological linkage reflects the ebb and flow of negative affect, the escalation and de-escalation of conflict, and the sense of being "locked into" the interaction and unable to "step back" that can occur when spouses in dissatisfied marriages attempt to solve problems and when this kind of patterned conflict occurs in other dyadic interactions. If the finding replicates and this speculation as to its basis is true, then measures of physiological linkage may capture a heretofore elusive quality of distressed interaction. The feeling of being "trapped" and locked into destructive interactions within intimate relationships is not uncommon. If methods are developed to identify instances of these interactive patterns reliably, then we would predict that it would be at those times that physiological linkage would be at its strongest.

Stepping back from the data, it seems we have chosen to study a very important topic—marital satisfaction—in a somewhat unusual way. First, we have relied heavily on the self-reports of our subjects. Second, we have attempted to relate marital satisfaction to physiology, using traditional intraindividual and new interindividual physiological measures. Finally, we provided only minimal structure and allowed couples to interact quite freely. Despite this, we found that during these interactions all of our measures bear strong and nonredundant relations to marital satisfaction. Together, physiological linkage, intraindividual physiological measures, and self-reported patterns of affect exchange have the potential to account for much of the variance in marital satisfaction; thus, we are encouraged to continue this approach in our studies of affect and of relationship satisfaction.

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