INTERACTIVE EFFECTS OF DAILY NONVERBAL AND VERBAL PAIN EXPRESSION ON
SPOUSE RESPONSES IN OSTEOARTHRITIS: EMPIRICAL EVIDENCE FOR A
COMMUNICATION MODEL

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Abstract

The current study applied models of pain communication and dyadic process to examine the distinction between verbal and nonverbal channels of pain expression in their prediction of punishing, empathic, and solicitous spouse responses. It was hypothesized that greater nonverbal expression would be related to more punishing and less empathic and solicitous responses. Verbal expression was expected to share a negative association with punishing responses and positive relation with empathic and solicitous reactions. Last, it was anticipated that any negative relationship between patient nonverbal pain expression and spouse responses would be buffered, or weakened, on days when levels of verbal pain expression were high.

With an innovative 22-day diary design, 144 individuals with knee osteoarthritis and their spouses completed daily measures of pain expression, spouse responses, health, and affect. The predicted positive relationship between verbal expression and empathic and solicitous responses was supported by the data. However, greater nonverbal pain expression related to more, not less, empathic and solicitous responses. Results partially supported the moderation hypothesis in that there arose an enhancing, rather than a buffering, effect of verbal pain expression on the relationship between nonverbal expression and empathic responses. That is, the link between nonverbal pain expression and empathic reactions was not significant on days when patients shared little pain verbally. Alternatively, on days when patients verbally expressed their pain very much, their nonverbal pain expression was positively related to empathic spouse responses. These findings underscore the importance of the pain transaction across both verbal and
nonverbal modes of expression for the receipt of spousal support. Implications for the pain communication model and for other relevant theoretical perspectives are discussed.
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Chapter 1

**Literature Review**

Pain is a social experience. Not only can the presence of a close other assuage the aversive neural response to pain (Coan, Schaefer, & Davidson, 2006), but also evolutionary incentives encourage those in pain to express it to others. Indeed, communicating pain can elicit responses from social partners that may both benefit the pain sufferer and maintain the safety and well-being of the group (Hadjistavropoulos et al., 2011). However, when pain is chronic, the social dynamics of its expression seem especially complex. If the sufferer continues with verbal and nonverbal requests for emotional and physical support, benevolent responses may devolve into more volatile and punishing ones (McCracken, 2005), and social connections themselves may weaken (Bolger, Foster, Vinokur, & Ng, 1996; Crouch, Skowronski, Milner, & Harris, 2008; Kaniasty & Norris, 1993; Moyer & Salovey, 1999; Norris & Kaniasty, 1996; Quittner et al., 1990).

As a leading contributor to disability and missed work, chronic pain is also of growing public health concern (Institute of Medicine, 2011). According to a 2006 report by the National Center for Health Statistics, more than two thirds of adults in the United States who endorsed having experienced any pain in the past month had suffered from that pain for one month or longer. Almost half of those who reported pain indicated its duration as longer than one year. Given both medical expenses and losses in productivity, the cost of chronic pain in the United States is estimated at an annual $635 billion (Institute of Medicine, 2011).

Though the pain experience can theoretically be influenced by any social tie, marriage is the central relationship for most middle-aged and older adults, who comprise
the majority of those with chronic pain. A multitude of studies have demonstrated the profound and multidimensional influence of marriage on physical health (e.g. Cacioppo, Bernston, Sheridan, & McClintock, 2000; Kiecolt-Glaser & Newton, 2001; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). The role of the spouse can be especially critical when an individual struggles with an existing health challenge, and indeed, spousal interactions have been shown to impact chronic pain patients’ functioning (Schmaling & Goldman-Sher, 2000).

Therefore, to focus the review of extant literature regarding pain expression and its personal and social consequences, the experience of chronic pain will be considered specifically among couples.

**Two Modes of Pain Expression**

Pain expression can be accomplished nonverbally—by grimacing, bracing, joint-guarding, groaning, limping—or verbally. Nonverbal acts, our very first expressive tools as infants, are considered to function more automatically and without much conscious control. Nonverbal expressions can also present in a nonspecific and ambiguous way, such that observers certainly perceive distress but may not decode its origin or intensity accurately (Craig, 2009). Verbal expression, also referred to as disclosure, implies command of the shared language and also much executive control. Therefore, partners may more likely receive a clear, precise message regarding the intensity and location of the pain, but that communication may be filtered by the individual in pain and the partner according to the personal, social, and cultural context.

**Categories of Spouse Responses to Pain**

Spouse responses have been typologized in a variety of ways. Solicitous responding to pain cues entails the provision of seemingly unnecessary assistance—for example, by
encouraging the pain sufferer to rest, and offering analgesics or food and drink. Spouses can also employ distracting techniques, such as reading to the partner in pain, involving him or her in activities, or encouraging participation in a hobby (Kerns, Turk, & Rudy, 1985). Another type of spouse response is considered punishing, characterized by irritation, ignoring, and hostility. Akin to punishing responses are aggressive responses, marked by sarcasm and anger (Romano et al., 1991). Empathic responses include affection, active listening, and perspective taking. Responses considered facilitative closely resemble empathic ones in that they are colored by positivity and care (e.g., encouragement in tasks, humor, compliments; Romano et al., 1991).

**Pain Behaviors and Spouse Responses: A Behaviorist Tradition**

Beginning in the 1970s, researchers and physicians looked to the marital relationship to understand an unexplained perpetuation of pain experienced by many patients. Through an operant conditioning lens, the idea of “sick-role homeostasis” took hold, wherein behaviors and outcomes strengthen or abate vis-à-vis reinforcement contingencies (Fordyce, 1976; Kremer, Sieber, & Atkinson, 1985; Raichle, Romano, & Jensen, 2011; Romano et al., 1995; Romano et al., 1992). More specifically, “pain behaviors”—that is, any acts that indicate pain to others—were often found to increase the likelihood of pain-reinforcing responses, such as solicitousness, which in turn increased patient reports of pain and disability (Paulsen & Altmaier, 1995; Pence et al., 2008; Romano et al., 1995; Romano et al., 1992; Turk, Kerns, & Rosenberg, 1992). This relationship between pain behaviors and solicitous spouse responses has been demonstrated via patient report and observational data (Pence, Thorn, Jensen, & Romano, 2008; Romano et al., 1992).
In the overwhelming majority of studies that follow the dominant stimulus-response framework, no distinction has been made between nonverbal pain behaviors and verbal ones in their relationship to spouse responses (e.g., Cano, Barterian, & Heller, 2008; Feldman, Downey, & Schaffer-Neitz, 1999; Kerns et al., 1991; Papas, Robinson, & Riley, 2001; Pence et al., 2008; Raichle et al., 2011; Romano et al., 1995), with the exception of two notable studies. Using a behavioral coding scheme, Romano and colleagues (1991) discriminated between nonverbal and verbal pain behaviors, as well as among facilitative, aggressive, and solicitous spouse responses, and compared relative frequencies of these pain behaviors and responses as employed by chronic pain and control couples. In a follow-up study, Romano and others (1992) applied this coding system and found that nonverbal pain behaviors were followed by solicitous spouse responses in chronic pain couples more frequently than in control couples. However, the authors found no significant difference between couples with chronic pain and control couples in the frequency of spouses’ solicitous, facilitative, or aggressive responses that followed patients’ verbal pain expressions. The researchers attributed these null effects to the low frequency and reliability of verbal pain behaviors, as well as variability in solicitous behavior preceding and following verbal expressions as compared to nonverbal pain expressions. None of the statistical analyses directly tested the relationship between pain expressions and spouse responses within couples. Instead, they assessed group mean differences between chronic pain and control couples in the frequencies of these expression-response pairings.

In subsequent studies, nonverbal and verbal pain expressions have not been distinguished. Romano and colleagues (1995) supplemented the coding system, sans verbal pain expression, with the Pain Behavior Checklist (PBCL; Kerns et al., 1991)—a four-
subscale measure that conflates verbal and nonverbal pain expression. They found no relationship between this measure and solicitous spouse responses—an unsurprising pattern, as nonverbal pain behaviors were found to hold positive correlations with some PBCL subscales while verbal pain behaviors shared no relationship with any of the scales (Romano et al., 1991). Recent publications continue to utilize pain behavior measures characterized by an unclear amalgam of verbal and nonverbal pain acts (e.g. Pence et al., 2008; Raichle et al., 2011; Romano, Jensen, Schmaling, Hops, & Buchwald, 2009; Schwartz, Jensen, & Romano, 2005). With the use of undifferentiated scales, pain behaviors have most consistently shared positive relationships with solicitous and punishing spousal responses, such that patients who display more pain behaviors have spouses who respond in more solicitous and punishing ways (Papas et al., 2001; Pence et al., 2008; Raichle et al., 2011; Schwartz, Slater, & Birchler, 1996).

One study outside of the behaviorist tradition that examined separate reports of nonverbal pain behaviors and verbal pain disclosure showed that more nonverbal pain behaviors predicted higher levels of critical attitudes in spouses (Stephens, Martire, Cremeans-Smith, Druley, & Wojno, 2006). The authors also reported a non-significant association between nonverbal pain behaviors and emotional support from spouses. Thus, it appears that disentangling the two routes of pain expression may reveal that nonverbal pain behaviors evoke a negative spouse response.

**Verbal Pain Expression and Spouse Responses**

Likewise, surprisingly little empirical research has assessed the effect of verbal pain expression on spouse responses. Again, Romano et al. (1992) found that verbal pain behaviors did not predict solicitous, facilitative, or aggressive spouse responses in chronic
pain couples any more than in control couples. However, Stephens et al. (2006) did find that verbal pain disclosure was positively related to emotional support and not significantly correlated with husbands’ critical attitudes. Nevertheless, this effect of verbal pain disclosure on spouse emotional support was qualified by an interaction that showed patients who disclosed much but experienced less severe pain received more spouse emotional support than patients who disclosed much about their pain and reported more severe pain. So, those with severe pain did not benefit from high disclosure in terms of spouse emotional support compared to those with a high level of pain who disclosed little. This finding reflects a pattern consistent with social support deterioration, a model that describes the depletion of support from others over time as an individual experiences a chronic stressor (Kaniasty & Norris, 1993; Kelley & McKillop, 1996).

Results in the disclosure literature seem to collectively suggest that verbal pain expression shares a positive relationship with spouse functioning and response. Porter and colleagues (2008) showed that arthritis patients’ self-efficacy for communicating their pain was negatively associated with partners’ negative affect. They also found that patients’ holding back from communicating about pain and arthritis concerns was related to greater caregiver strain among spouses. The relationships between verbal pain disclosure and spouse outcomes were not reported, though holding back and disclosing have consistently shared a negative correlation in past work (Pistrang & Barker, 1995; Porter, Keefe, Hurwitz, & Faber, 2005). In short, the few published studies related to verbal pain expression seem to support that verbal disclosure of intense pain may erode social support by depleting spouse resources, but that patient efficacy for pain communication
may also be protective and purposive avoidance of verbal pain disclosure, harmful, for spouses.

Research regarding the broader construct of illness-related disclosure has largely corroborated the positive relationship between verbal pain disclosure and spouse responses. This consistency in results across disclosure constructs is not surprising given that when asked to freely name a confidant and most common illness concern, the majority of patients cited the spouse as their most important confidant, and physical symptoms as one of their most frequently discussed topics (Figueiredo, Fries, & Ingram, 2004; Pistrang & Barker, 1992; Porter et al., 2005). Consistent with Porter et al. (2008), in a study of patients with gastrointestinal cancer and their spouses Porter and colleagues (2005) examined patient and spouse reports about their own disclosure and holding back of cancer-related concerns to find that greater patient disclosure predicted higher spouse-reported intimacy and that greater patient holding back was related to greater spouse criticism.

Arguments substantiating this hypothesis of global positive effects for disclosure include that expression leads to more congruent understandings of the patient’s condition between patient and spouse or family member (Porter et al., 2005). Indeed, greater pain concordance, or agreement between patient and family member regarding the patient’s pain severity, has been associated with more sensitive spouse responses and lower caregiver strain (Manne & Zautra, 1989; Redinbaugh, Baum, Demoss, Fello, & Arnold, 2002). Also, Martire and colleagues (2006) found that pain concordance between patient and spouse was related to fewer punishing spouse responses as compared to spousal overestimation of patient pain. Other supporting arguments draw from research on
relationship intimacy in chronic illness and the efficacy of emotional disclosure interventions, as described in the following sections.

**Disclosure and relationship intimacy.** Relationship researchers have empirically demonstrated the link between disclosure and marital intimacy and quality (Chelune, Vosk, Waring, Sultan, & Ogden, 1984; Merves-Okin, Amidon, & Bernt, 1991). Manne et al. (2004) tested and supported a model of intimacy in chronic illness among breast cancer patients and their partners wherein partner disclosure and perceived partner responsiveness led to increased feelings of relationship intimacy for both patient and spouse. Also, Pistrang & Barker (1995) found in a breast cancer study that patient relationship satisfaction, perceived helpfulness of disclosure, and perceived partner empathy were all positively interrelated. Further, Porter et al. (2005) found that more patient disclosure and less patient holding back were both related to greater spouse-reported relationship intimacy.

According to this intimacy-oriented line of reasoning, patient pain disclosure may contribute to the closeness of the relationship, creating a warm relational atmosphere and, therefore, encouraging more empathic responses and fewer punishing ones. Indeed, Cano, Weisberg, and Gallagher (2000) established that greater spouse marital satisfaction was related to fewer negative spouse responses to pain in a chronic pain sample. However, Newton-John and Williams (2006) found that spouses’ marital satisfaction did not significantly benefit from more frequent patient pain talk. Thus, it is unsettled whether the association between disclosure and positive spouse responses holds in the domain of chronic pain.

**Disclosure interventions.** Most emotional disclosure interventions for chronic illness populations have not focused on patient-spouse dyads. An exception is a study by
Porter and colleagues (2009) testing a partner-assisted emotional disclosure intervention in a cancer sample wherein patients were asked to disclose a strongly emotional cancer-related experience to their spouses, who were trained to respond in a reflective, supporting way. Compared to an education-only condition, dyads who received the emotional disclosure intervention reported higher post-intervention marital quality and intimacy for patients who endorsed high levels of holding back pre-intervention. Again, if collaborative disclosure enhances a spouse’s feelings of intimacy and marital satisfaction, perhaps their responses become more empathic and less punishing as well.

**Joint Consideration of Verbal and Nonverbal Expressions**

In short, the literatures of social support and disclosure stand at odds due to a difference in their constructs of focus. The former has drawn a general conclusion that pain behaviors, verbal and nonverbal alike, work to erode spouse resources and empathic support for the patient, and that solicitous responses reinforce the use of pain behaviors. Deductions from the disclosure literature frame verbal disclosure and openness as helpful for the relationship and, inherently, the individuals in the partnership.

As elaborated in the following section, two frameworks underscore the value of examining the interactive influence of verbal and nonverbal pain expression on spousal responses rather than studying these two modes of pain expression in isolation or in an undifferentiated way.

**Pain communication model.** Hadjistavropoulos et al. (2011) proposed a framework for pain communication between two interlocutors wherein pain expression—verbal or nonverbal—may contribute to the product of action, interaction, or transaction. The act of pain expression may remain a mere action when its message does not reach the
receiver. When pain expression leads to interaction, a message may be received, but perhaps nothing is done further. However, when pain is transacted, the message is received and acted upon in some way. So long as the relationship between the sufferer and listener is good and the listener does not feel an immediate threat, he or she is expected to react in a helpful, benevolent way (Goubert et al., 2005). In both scenarios of interaction and transaction, pain expression may be misinterpreted by the listener. Failure to convey an accurate message that elicits a favorable outcome does not necessarily reflect the fault of either the sender or receiver.

Though it is possible for nonverbal and verbal modes of pain expression to each solely (independent of the other mode) account for a “successful” transaction, or one that results in empathic spouse responses, because nonverbal expression can be considered less precise it may contribute to the development of maladaptive communicative transactions, confusing and frustrating spouses as well as increasing their likelihood for punitive responses. That is, the relationship between pain behaviors and punishing spousal responses made ambiguous by the combination of nonverbal and verbal pain expressions may have been driven by a predominance of nonverbal pain expression (Schwartz et al., 1996). Supporting evidence from the infant pain literature suggests persistent crying—nonverbal behaviors lacking specific information about the experience of pain—attenuates parent-infant bonds and increases the potential for physical abuse (Crouch, Skowronski, Milner, & Harris, 2008).

On the other hand, distinct from a rationale of the general disclosure literature that verbal expression benefits patients and partners by bolstering relationship quality and thus infuses the spouse with more empathy, the communication model would emphasize
the precise, clarifying nature of verbal expression that allows a positive, caring response. Likewise, the pairing of verbal with nonverbal pain expression should buffer patients from punishing spouse responses that otherwise may be evoked by perhaps more ambiguous nonverbal expression, increasing the likelihood of a clear transaction of the pain experience and resulting in fewer punishing and more empathic and solicitous responses.

**Developmental-contextual model.** In a dyadic model of chronic illness, Berg & Upchurch (2007) posit an ever-present link between patient and spouse illness appraisals—the conduit joining patient pain expression to spousal responses. More specifically, the patient’s nonverbal and verbal pain expression can be conceived as representing his or her appraisal of the experience, influencing the spouse’s appraisal of the patient’s condition and, therefore, impacting the way the spouse copes—in this case, the spouse’s punishing, empathic, and solicitous responses to the patient.

This relationship between pain expressions and spouse responses has implications for profound mutual influence and change. As couples communicate their illness-relevant beliefs, attitudes, and experiences, they influence each other’s appraisals and, in so doing, may shape their actual coping behaviors, which can range from uninvolved to supportive, to collaborative, to controlling. Indeed, in an iterative way, the spousal response affects the patient’s coping with pain, a pattern that has been demonstrated in the prediction of pain behaviors from solicitous spouse responses (e.g. Lousberg, Schmidt, & Groenman, 1992).

Unfortunately, most previous research that has examined couples living with chronic illness has not assessed the spouse (Figueiredo et al., 2004; Papas et al., 2001; Pence et al., 2008; Pistrang & Barker, 1992), especially for the spouse’s perceptions of patient pain communication (Stephens et al., 2006; Porter et al., 2008). Therefore, up to
this point, analytically there has been no way to operationalize a truly dyadic model of verbal and nonverbal pain communication. It is also important to consider that dyadic appraisals and coping arise in daily life, in everyday conversation—measured best by daily or momentary assessments rather than one-time reports that represent the average experience of these phenomena.

**Daily Assessment of Chronic Illness**

Daily diary and ecological momentary assessment (EMA) approaches have been applied to chronic pain samples in an effort to understand relationships among pain, affect, disability, various illness management styles, and efficacy (Affleck, Urrows, Tennen, & Higgins, 1992; Affleck et al., 1999; Holtzman & Delongis, 2007; Keefe et al., 1997; Peters et al., 2000; Sorbi et al., 2006). Daily assessments prove particularly useful because reports can be distorted by the present psychological state, such as perceptions of current pain (Baliki, Geha, & Apkarian, 2009; Erskine, Morley, & Pearce, 1990; Tennen & Affleck, 1996). Indeed, more frequent time series attempt to minimize recall errors and bias. Also, these techniques more closely approximate the time course of the processes under study (Affleck, Tennen, Urrows, & Higgins, 1991; Bolger, Stadler, Paprocki, & Delongis, 2010), as couples engage in pain expression and responses to pain on a daily basis. Little is known, however, about the frequency or variability of pain expression and spousal reactions, or about the daily covariation of pain expression and spouse responses.

The failure to replicate between-person findings at the within-person, across-day level has bolstered support for these finer-grained time scales. For instance, Keefe and colleagues (1997) found that coping efficacy reported on one day predicted pain and coping strategy use on the same day, as well as the next day's pain, though corresponding
between-person relationships were not significant. Also, widely used one-time, retrospective measures of pain and spouse responses, such as the Multidimensional Pain Inventory (MPI), have been weakly or not associated with their daily counterpart items (Lousberg, Schmidt, Groenman, Vendrig, & Dijkman-Caes, 1997; Peters et al., 2000). In short, in some cases daily phenomena seem to reflect qualitatively different processes that warrant further study.

**Current Study**

The current study attempted to capture the relationship between daily pain expression and spouse responses in patients with osteoarthritis (OA) and their partners. OA is a degenerative disease affecting the joints and is the most common chronic illness among older adults (Corti & Rigon, 2003). The number of older adults diagnosed with OA increased to 26.9 million in 2005 from 21 million in 1990 (Lawrence et al., 2008). Hip and knee OA are among the most prevalent causes of pain and can profoundly limit functional ability given their effects on mobility (Corti & Rigon, 2003; Guccione et al., 1994). Despite public health significance and the fact that many older adults with OA are married or partnered, few daily studies of OA have been dyadic in nature.

In the current study patients were asked each day for 22 consecutive days to rate their spouses’ degree of solicitous, punishing, and empathic responses, and spouses reported how much patients verbally described and nonverbally displayed pain. Whereas other dyadic studies have examined between-couple, patient-perceived trends of verbal and nonverbal expression, this novel within-couple approach was designed to uncover the daily interplay of verbal and nonverbal pain transaction efforts as they relate to spouse responses previously veiled both in magnitude and direction by between-person patterns.
Hypotheses

Hypotheses for the current study were as follows:

\( H_1 = \) Greater patient nonverbal pain expression on a given day will be associated with fewer empathic and solicitous responses as well as more punishing responses from the spouse on that day.

According to the pain communication model, nonverbal pain expression may be ambiguous enough to fail in transacting the message of pain to the spouse, decreasing the likelihood of supportive spouse responses. At the conceptual level, solicitous responses closely mimic empathic ones, as they demonstrate care and concern; therefore, nonverbal pain expressions are predicted to also be associated with a decrease in solicitous responses.

\( H_2 = \) Greater patient verbal pain expression on a given day will be associated with more empathic and solicitous responses as well as fewer punishing responses from the spouse on that day.

Stephens et al. (2006) suggested that verbal disclosure of intense pain may erode supportive responses by depleting spouse resources. However, the pain communication framework indicates that positive, benevolent reactions are expected from listeners who who successfully receive the pain message, a goal made likely by the specificity of verbal disclosure.

\( H_3 = \) Daily verbal pain expression will moderate (i.e., buffer) the associations between daily nonverbal pain expression and spouse responses. Specifically, the negative associations between daily nonverbal pain expression and spouse responses will be
weaker on days when the patient verbally discloses much pain, as compared to days when the patient discloses his or her pain less.

As aforementioned, verbal pain expression is hypothesized to mitigate the negative effects of nonverbal pain expression due to the ability to describe and clarify the nuances of patient pain.
Chapter 2

Method

Study Design

Data presented in this report were extracted from a larger study of patients diagnosed with knee osteoarthritis (OA) and their spouses that combined in-person interviews conducted over an 18-month period (i.e., T1, T2 at a 6 month follow-up, and T3 at an 18 month follow-up) with a 22-day assessment of daily experiences immediately after the T1 interview. During the daily assessment protocol, patients and spouses used a handheld computer to answer questions regarding health and affect three times per day (i.e., beginning-of-day, afternoon, and end-of-day), and questions regarding marital and pain-related interactions at end-of-day. Both patient and spouse also wore an accelerometer in order to provide objective data on daily physical activity during the 22-day period. After the study, each individual participant was compensated up to $225 (i.e., $25 for each of the 3 interviews and up to $150 for the daily assessments). The current report utilizes data from the T1 interviews and end-of-day diary assessments.

Participants

To be eligible for the study, patients had to be diagnosed with knee OA by a physician, experience usual knee pain of moderate or greater intensity, be at least 50 years of age, and be married or in a long-term relationship (self-defined) in which they shared a residence with their partner. Exclusion criteria were a comorbid diagnosis of fibromyalgia or rheumatoid arthritis, use of a wheelchair, or a plan to have hip or knee surgery within the following six months. Couples were excluded from the study if the spouse reported arthritis pain of moderate or greater intensity, used a wheelchair, or required assistance
with personal care activities. Both partners were required to be cognitively functional as indicated by the accuracy of their answers to questions regarding the current date, weekday, their age, and birthdate. Both partners also had to be free of any major hearing, speech, or language problems that would interfere with the comprehension and completion of data collection conducted in English.

Primary sources of recruitment were research registries for rheumatology patients and older adults interested in research in the Pittsburgh area, flyers distributed to University of Pittsburgh staff and faculty, and word of mouth. A total of 606 couples were screened for eligibility. Of these, 221 couples declined to participate, and the most frequent reasons were lack of interest (N = 87) or illness in the family (N = 55). A total of 233 couples were not eligible, and the most frequent reasons were lack of OA in the knee (N = 55) or knee OA pain that was mild (N = 47). The total enrolled sample was comprised of 152 couples (i.e., 304 individuals). A total of 145 couples completed the diary assessment component of the study, and 144 couples provided sufficient data to be included in analyses. Table 1 provides background information for these patients and their spouses.

**Data Collection Procedure**

Trained staff interviewed patients and spouses separately in each home. Following the interviews, couples were trained to use the handheld computer (i.e., the Palm TX) as well as familiarized with the format and content of the diary questions. The handheld computer and questionnaire were designed for easy use by older adults and people with minimal computer experience; accessible features included large font size and an oversized stylus for registering responses. Each patient and spouse was provided with a handheld computer that was clearly labeled with his or her name, and the importance of completing
diary assessments independently was emphasized. Surveys were intended to be completed in the morning, afternoon, and evening. More specifically, participants were instructed to answer questions: 1) within 60 minutes of rising in the morning, 2) between 2:00 and 4:00 P.M., and 3) upon retiring at night. Questions of the current study are restricted to end-of-day assessments.

Completion and compliance rates were examined for the diary data. Out of a potential 6380 end-of-day observations (290 individuals in 145 couples x 22 days), a total of 5863 were completed (92%). Compliance with the requested timing of the end-of-day assessment was evaluated by comparing the time of the handheld computer entries with participants’ written log of daily bedtimes. End-of-day assessments that were completed more than 120 minutes before bedtime were excluded from analysis. Using this criterion, 5327 of the 5863 completed observations were included in analysis (i.e., 92% of the completed observations, or 83% of the total possible observations). Completion and compliance rates were very similar for patients and spouses.

Measures

**Nonverbal pain expression.** Patient nonverbal pain expression was assessed by the spouse at the end of each day with the following 3-point scale item developed for this study (1 = not at all, 2 = somewhat, 3 = very much): “Today, did your spouse show how much pain he/she was experiencing with facial expressions, noises, changes in mood, or the way he/she moved around?”

**Verbal pain expression.** Patient verbal pain expression was assessed by the spouse at the end of each day with the following 3-point scale item developed for this study (1 = not at all, 2 = somewhat, 3 = very much): “Today, to what extent did your spouse describe
his/her pain to you?” Patients also rated their own verbal pain expression, but their reports were not the focus of the current study and were, therefore, excluded.

**Spouse responses to patient pain.** Spouse responses to patient pain were assessed by patient report at the end of each day with 9 Likert-type items (1 = not at all, 2 = somewhat, 3 = very much). Spouses also rated their own responses to patient pain, but their reports were not the focus of the current study. Six of the items were adapted for daily assessment from the West Haven-Yale Multidimensional Pain Inventory (Kerns, Turk, & Rudy, 1985). Three of these items were intended to measure solicitous, or excessively helpful, spouse behaviors such as offering food or drink, taking over tasks, and encouraging rest (e.g. “Today, your spouse took over your jobs or duties to help you avoid pain”). The other three items were designed to assess punishing behaviors—ignoring, acting frustrated, and seeming irritated. An example includes “Today, your spouse got frustrated with you when you seemed to be in pain.” The three remaining items, intended to measure empathic responses, were adapted from a scale assessing spouse emotional support in response to patient pain (Stephens et al., 2006). Items refer to showing affection, understanding patient feelings about the pain, and providing attention (e.g. “Today, your spouse tried to just be there for you when you seemed to be in pain, by giving you his/her undivided attention).

**Multilevel Exploratory Factor Analysis (EFA).** Because none of the nine items had been examined at the daily level, a two-level EFA was conducted to investigate the factor structure of spouse responses at both between-couple and within-couple levels. Using Mplus version 6.1 (Muthen & Muthen, 2010), factor parameters were specified such that solutions ranged from one factor for each level to three factors for each level. Accordingly,
all possible combinations of factor structures were generated with and without an oblique Geomin rotation, as were their respective fit statistics. Unrotated factor loadings are presented in Table 2 along with root mean squared error of approximation (RMSEA), Confirmatory Fit Index (CFI), and \( \chi^2 \) values.

As shown in Table 2, a one-factor within-person, one-factor between-person solution did not fit the data well, as RMSEA and CFI indicators did not meet their recommended cutoff values of .06 and .95, respectively (Hu & Bentler, 1999). Further, for both within- and between-couple levels, items intended as punishing responses (Items 2, 6, and 9) loaded very weakly onto the factor. The multilevel two-factor solution represented a statistically significant improvement to the fit of the data in comparison to the one-factor according to a \( \chi^2 \) change test (\( \chi^2(16) = 1106.2, p < .001 \)), as well as a good fit overall (RMSEA = .04; CFI = .96). The within- and between-person solutions approximated simple structure, with high loadings of items intended as solicitous and empathic on one factor (Items 1, 3, 4, 5, 7, and 8) and high loadings of punishing items on the other factor (Items 2, 6, and 9). Some items weakly cross-loaded onto the opposite factor in the negative direction. As expected, adding a third factor to both within- and between-person levels improved model fit from the two-factor solution (\( \chi^2(16) = 186.7, p < .05 \)). For this reason and because of the conceptual precedent, the three-factor solution was chosen as the final solution. Nevertheless, in accordance with the simple structure of the two-factor solution, a composite scale consisting of solicitous and empathic items was created and labeled “concerned responses” to explore this factor of spouse response patterns at the daily level.

**Punishing, solicitous, and empathic responses.** Items 2, 6, and 9 were summed to produce a punishing scale ranging from 3 to 9, with higher scores indicating more
punishing responses. To capture each scale’s reliability at both between- and within-person levels, generalizability coefficients were estimated according to an established method of variance partitioning (Cranford et al., 2006). Reliability of the punishing response scale was low overall, .55 at the between-person level and .50 at the within-person level. Solicitous items—1, 3, and 5—were added together, creating a range of 3 to 9, with higher values reflecting more solicitous spouse behavior. Between-person reliability was estimated to be .81, and within-person was .58. The empathic scale was constructed by summing items 4, 7, and 8, ranging from 3 to 9, with higher scores meaning more empathic responses. Reliability coefficients indicated good internal consistency ($R_{between} = .86$, $R_{within} = .67$).

**Concerned responses.** In accordance with the two-factor solution produced by the EFA, empathic and solicitous subscales were combined into one scale deemed “concerned” responses. As a simple sum of the two scales, the concerned response scale ranged from 6 to 18, with higher scores reflecting perceptions of more concerned spouse behaviors. As expected, internal consistency of the scale was higher than that of the others ($R_{between} = .89$, $R_{within} = .74$).

**Marital satisfaction.** The 10-item dyadic satisfaction subscale of the Dyadic Adjustment Scale (Spanier, 1976) was used to measure overall, between-person marital satisfaction. Of the 10 items, 7 lie on a 6-point scale of 0 - 5 (all the time – never) and inquire about frequency of negative relational events: “How often do you discuss or have you considered divorce, separation, or terminating your relationship?” One item assess how frequently the responder kisses his or her spouse on a scale of 0 – 4 (never – every day). Another item probes happiness in the relationship on a 7-point scale (0 = extremely
unhappy; 6 = perfect). The last 6-point Likert item taps into feelings about the relationship’s future, ranging from “My relationship can never succeed, and there is no more that I can do to keep the relationship going” to “I want desperately for my relationship to succeed, and would go to almost any length to see that it does.” All 10 item scores were summed to create a total score that could range from 0 to 50. Patients and spouses in this sample averaged much above the midpoint, indicating very high marital satisfaction ($M_{pt} = 39.61, SD_{pt} = 6.26; M_{sp} = 38.94, SD_{sp} = 6.47$). Internal consistency was acceptable for both patient and spouse reports ($\alpha_{pt} = .89; \alpha_{sp} = .87$).

**Covariates.** Covariates were chosen on a conceptual basis. Both patient and spouse reported their own negative affect, marital enjoyment, marital tension, and patient pain severity at the end of day. Because patients’ experience of pain serves as an interpretive backdrop that may color their perceptions of spouse responses and since spouses’ judgment of patient pain is related to patient expression of pain, both reports of patient pain were included as important covariates. Furthermore, Stephens et al. (2006) found that patients who experienced a high level of pain and also expressed it verbally had spouses who responded with less emotional support. Patient pain severity was assessed with one item at end-of-day in the daily diary: “How would you describe your [spouse’s] overall arthritis pain today?” Responses ranged from 0 (none) to 3 (severe).

End-of-day negative affect of both patient and spouse was included to account for any negative response biases in the reporting of patient pain expression and spouse responses, as recent negative emotion may provide a context for negative interpretation of other events (Marco & Suls, 1993). End-of-day negative affect was assessed in reference to the prior 30 minutes: “To what extent have you felt [unhappy] over the past 30 minutes?”
Five items measured negative affect in terms of feeling depressed or blue, frustrated, angry or hostile, unhappy, and worried or anxious. Responses ranged from 0 to 6 (not at all to extremely), and all 5 items were summed to create a scale with potential scores of 0 to 30.

Because relationship quality has been strongly established as a generalized lens through which other, more specific marital interactions are viewed, (Kiecolt-Glaser & Newton, 2001; Turk et al., 1992), both partners’ daily marital interaction quality—tension and enjoyment—were taken into account as covariates. Patient and spouse completed one item for both tension and enjoyment at end-of-day on a scale of 1 to 3 (not at all, somewhat, very much): “Overall, how [tense / enjoyable] were your interactions with your spouse today?”

**Data Reduction and Analysis**

In preparation for data analysis, all daily predictors and covariates were person-mean centered. Next, a series of multilevel models were estimated using PROC MIXED in SAS 9.2 for the four primary outcomes—punishing, empathic, solicitous, and concerned spouse responses. All models included a random intercept. For each outcome, the empty model was estimated first for the purpose of calculating the intraclass correlation coefficient. Next, covariates were entered. Then the main effects of daily nonverbal and verbal pain expressions were added to the model. The next model accounted for the interaction of daily nonverbal and verbal pain expressions. After that, the random slope of verbal expressions was added and evaluated with a log likelihood ratio test. Next, the random slope of nonverbal expressions was tested.\(^1\) The ESTIMATE command in SAS 9.2

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\(^1\) The random effect of the verbal X nonverbal pain expression interaction was evaluated in the final model for each outcome, but these models are not presented in the body of the Results section. Documentation of log likelihood statistics can be found in corresponding tables.
was used to probe significant interactions in the final solutions. The following equations represent the general structure for all four sets of models:

Level 1:

\[ \text{Response}_{ti} = \beta_{0i} + \beta_{1i}(PtPain_{ti}) + \beta_{2i}(SpPain_{ti}) + \beta_{3i}(PtNA_{ti}) + \beta_{4i}(SpNA_{ti}) \]
\[ + \beta_{5i}(PtTense_{ti}) + \beta_{6i}(PtEnjoy_{ti}) + \beta_{7i}(SpTense_{ti}) \]
\[ + \beta_{8i}(SpEnjoy_{ti}) + \beta_{9i}(Verbal_{ti}) + \beta_{10i}(Nonverbal_{ti}) \]
\[ + \beta_{11i}(Verbal_{ti})(Nonverbal_{ti}) + \epsilon_{ti} \]

Level 2:

\[ \beta_{0i} = \gamma_{00} + u_{0i} \]
\[ \beta_{1i} = \gamma_{10} \]
\[ \beta_{2i} = \gamma_{20} \]
\[ \beta_{3i} = \gamma_{30} \]
\[ \beta_{4i} = \gamma_{40} \]
\[ \beta_{5i} = \gamma_{50} \]
\[ \beta_{6i} = \gamma_{60} \]
\[ \beta_{7i} = \gamma_{70} \]
\[ \beta_{8i} = \gamma_{80} \]
\[ \beta_{9i} = \gamma_{90} + u_{9i} \]
\[ \beta_{10i} = \gamma_{100} + u_{10i} \]
\[ \beta_{11i} = \gamma_{110} \]
Chapter 3

Results

Descriptive Statistics

Pain expression and spouse responses. As shown in Table 3, where within-person means, standard deviations, and correlations are provided, verbal pain expression across the 22 days averaged at 1.58 on a scale of 1 to 3 ($SD = 0.61$). The majority of variability in verbal pain expressions was attributed to within-person differences (63%, $ICC = .37$). The mean of nonverbal pain expressions was similar ($M = 1.59, SD = 0.63$), and more than half of variability in nonverbal pain expression was due to within-person differences (53%, $ICC = .47$). The within-person correlation of verbal and nonverbal pain expressions was strong, indicating consistent covariation in the two modes of pain expression at the daily level ($r = .52, p < .0001$).

As depicted in Table 3 and Figures 3 and 4, spouse punishing responses varied somewhat across the 22 days and averaged at the low end of the scale, suffering from what appears to be a considerable floor effect ($M = 3.25, SD = 0.69$). The intraclass correlation coefficient (ICC) for punishing responses was .39, indicating that 39% of the variability in spouse punishing responses could be accounted for by between-person differences and 61% by across-day differences. Thus, there was a sufficient percentage of variability to warrant within-person analysis. As shown in Table 3 and Figures 5 and 6, variability in empathic spouse responses spanned the whole scale, and 34% of this variation was accounted for by across-day differences ($ICC = .66$). On average, empathic responses clustered slightly above the mid-point ($M = 5.17, SD = 0.63$). As shown in Figure 7, solicitous responses also spanned the scale but averaged just below the mid-point at 4.48
Variability in solicitous responses attributable to within-person differences was similar to that of empathic responses (35%, ICC = .65, See Figure 8). As depicted in Figure 9, on average spouses appeared to respond in a moderately concerned way, with great variability (M = 9.61, SD = 3.22). The composite scale of concerned responses was variable largely in terms of between-person differences (ICC = .69), yet 31% of variability could be explained by within-person differences (Figure 10).

As expected from the EFA solution, solicitous and empathic responses shared a very robust, positive correlation (r = .70, p < .0001). Their daily correlations with punishing responses were of small magnitude, however, as was the correlation between concerned responses and punishing ones (r_{empathic} = -.14, p < .0001; r_{solicitous} = -.06, p < .001; r_{concerned} = -.08, p < .0001). Correlations of verbal and nonverbal pain expression with empathic, solicitous, and concerned responses were moderately strong (rs = .21 to .32, ps < .0001). Correlations of verbal and nonverbal pain expressions with punishing responses were negligible (r_{verbal} = .02, p > .05; r_{nonverbal} = .10, p < .0001).

**Covariates.** According to both patient and spouse reports of patient arthritis pain severity, most days patients suffered between mild and moderate overall pain, with patients reporting slightly higher pain for themselves (M = 1.52, SD = 0.66) than spouses reported (M = 1.36, SD = 0.84). As expected, patient pain severity shared moderate-to-strong correlations with verbal and nonverbal pain expression as well as spouse responses (rs = .22 to .60, ps < .0001), with the exception of punishing ones (rs = .08 to .10, ps < .0001).

On a scale of 0 to 30, patients and spouses reported very low negative affect when asked to consider their mood up to 30 minutes before the bedtime survey, but they did
show great variability in these scores ($M_{pt} = 2.43, SD_{pt} = 4.33; M_{sp} = 2.07, SD_{sp} = 4.19$). Daily negative affect of both patient and partner was related positively to punishing responses, such that on days when patients and partners reported higher negative affect, patients perceived spouses to enact more punishing behaviors in response to their pain than on days when both reported lower negative affect ($r_{pt} = .27, p < .0001; r_{sp} = .13, p < .0001$). Also, on days when spouses reported perceiving more frequent nonverbal and verbal pain expression from patients, they felt more negative affect ($r_{verbal} = .12, p < .0001; r_{nonverbal} = .19, p < .0001$)².

On average, patients and spouses reported high enjoyment of their daily marital interactions ($M_{pt} = 2.44, SD_{pt} = 0.61; M_{sp} = 2.42, SD_{sp} = 0.57$) and low daily tension ($M_{pt} = 1.21, SD_{pt} = 0.46; M_{sp} = 1.23, SD_{sp} = 0.46$). Both patient and spouse marital enjoyment were positively related to patients’ perception of empathic and concerned spouse responses, such that on days when patients perceived more empathic or concerned responses from their spouses, both partners reported higher marital enjoyment than on days when patients perceived less empathic responses from the spouse ($r_{pt\text{ enjoy, empathic}} = .42, p < .0001; r_{sp\text{ enjoy, empathic}} = .19, p < .0001; r_{pt\text{ enjoy, concern}} = .34, p < .0001; r_{sp\text{ enjoy, concern}} = .13, p < .0001$). However, on days when spouses perceived more verbal and nonverbal pain expression from patients, they reported more marital tension ($r_{verbal} = .13, p < .0001; r_{nonverbal} = .23, p < .0001$). Both partners’ daily marital enjoyment and tension were related to punishing spouse responses in the expected directions. On days when patients and spouses reported enjoying their marital interactions more, patients endorsed less frequent punishing spouse responses ($r_{pt} = -.19, p < .0001; r_{sp} = -.12, p < .0001$). Conversely, on days when patients

² The small magnitude of both correlations cannot be attributed to the variability in spouse negative affect, as more than half was explained by within-person differences ($ICC = .49$).
and spouses reported more tense marital interactions, patients perceived that spouses responded with more punishing behaviors to their arthritis pain ($r_{pt} = .36, p < .0001; r_{sp} = .16, p < .0001$).

**Multilevel Models**

**Punishing spouse responses.** The final predictive model for punishing responses was determined by a log likelihood ratio test ($X^2(1) = 6.3, p = .011$) and included all covariates, main effects and interaction of verbal and nonverbal pain expression, and the random slope of verbal pain expression. In this model, as displayed in Table 4, the random intercept of punishing responses was statistically significant, such that some spouses were on average more punishing than others in response to patient pain ($\sigma^2_{u0} = 0.16, p < .05$). Also, most covariates were significant predictors of daily variability in punishing responses, and collectively they increased the fit of the model when they were originally entered, indicated by a reduction in fit statistic values of $-2LL$ and AIC.

Contrary to prediction, neither main effect of verbal or nonverbal pain expression nor the interaction between the two significantly predicted variability in punishing responses, though trends followed their expected directions ($ps > .05$). However, a significant random slope arose for verbal pain expression, such that the effect of verbal pain expression on punishing spouse responses varied significantly by couple ($\sigma^2_{u9} = .02, p < .05$).

**Empathic spouse responses.** The final model for empathic spouse responses was determined by a log likelihood ratio test ($X^2(1) = 24.7, p < .0001$) and included all covariates, main effects and interaction of verbal and nonverbal pain expression, and the random slope of verbal pain expression. As shown in Table 5, the random intercept of
empathic responses was significant, such that some spouses were on average more empathic than others in response to patient pain ($\sigma^2_{u0} = 2.26, p < .05$). Most covariates were significant predictors of empathic daily responses, and the set of covariates improved model fit, as indicated by lowered $-2LL$ and AIC.

Verbal and nonverbal patient pain expression also arose as significant predictors of empathic spouse responses. As hypothesized, on days when spouses perceived patient verbal pain expression to be more frequent, patients reported spouses as more empathic in response to their pain ($B = 0.37, SE = 0.07, p < .05$). Contrary to prediction, on days when spouses reported more frequent nonverbal pain expression from patients, they were more empathic rather than less empathic ($B = 0.14, SE = 0.06, p < .05$). The interaction of verbal and nonverbal pain expressions was statistically significant as well ($B = 0.17, SE = 0.08, p < .05$). As indicated in Figure 11, only on days when patients shared much pain verbally did greater nonverbal expression relate to more empathic responses ($B = 0.22, SE = 0.06, p < .05$). On days when patients shared little pain verbally, nonverbal pain expression was associated with neither more nor less empathic reactions ($p > .05$).

Further, Figure 11 reveals that spouses were most empathic on days when patients expressed pain both verbally and nonverbally more than the sample’s average amounts ($M = 5.41, SE = 0.13$). On days when patients expressed their pain very little, both verbally and nonverbally, they received the least empathic responses from spouses ($M = 4.93, SE = 0.13$). On days when patients nonverbally expressed their pain more than average but verbally disclosed their pain less frequently than usual, they fared only slightly better in terms of eliciting empathic spouse responses than those who had expressed their pain in neither mode ($M = 4.98, SE = 0.14$). On the other hand, on days when patients verbally expressed
more pain but showed their pain less than average, they received an average level of empathic response from spouses ($M = 5.20, SE = 0.14$).

The random slope of verbal pain expression was statistically significant, such that the relationship between daily verbal pain expression and daily empathic responses varied from couple to couple ($\sigma^2_{u9} = 0.17, p < .05$).

**Solicitous spouse responses.** The final model for solicitous spouse responses included all covariates, main effects and interaction of verbal and nonverbal pain expression, and the random slope of verbal pain expression, as determined by a log likelihood ratio test ($X^2(1) = 29.2, p < .0001$). As summarized in Table 6, the random intercept of solicitous spouse responses was statistically significant, such that on average some patients perceived more solicitous responses from their spouses than others did ($\sigma^2_{u0} = 1.74, p < .05$). Some covariates were significant, and they overall improved model fit when they were entered and thus were retained.

Both verbal and nonverbal pain expression arose as significant predictors of solicitous responses. As hypothesized, on days when patients expressed more pain verbally, spouses acted more solicitous in response ($B = 0.21, SE = 0.06, p < .05$). Contrary to prediction, on days when patients nonverbally displayed their pain more, spouses were perceived as responding more solicitously ($B = 0.19, SE = 0.05, p < .05$). In partial support of Hypothesis 3, the interaction between daily verbal and nonverbal pain expression was marginally significant in the final model ($B = 0.16, SE = 0.08, p = .085$). On days when patients shared much pain verbally, expressing more pain nonverbally was related to more solicitous spouse responses ($B = 0.25, SE = 0.06, p < .0001$). However, the positive association between nonverbal pain expression and solicitous responses was just
marginally significant in the presence of low verbal pain expression ($B = 0.12, SE = 0.07, p = .084$).

This interaction, depicted in Figure 12, shows that spouses were most solicitous on days when patients disclosed pain at high levels, verbally and nonverbally ($M = 4.67, SE = 0.12$). Spouses were least solicitous on days when patients expressed pain neither verbally nor nonverbally ($M = 4.29, SE = 0.12$). On days when patients expressed more verbally and less nonverbally ($M = 4.41, SE = 0.12$), spouses were perceived about as solicitous as they were on days when patients expressed more nonverbally and less verbally ($M = 4.41, SE = 0.12$).

The random slope of verbal pain expressions was statistically significant ($\sigma^2_{u9} = 0.17, p < .05$), suggesting that the relationship between daily verbal pain expression and solicitous spouse behavior varied across couples.

**Concerned spouse responses.** The final model for concerned spouse responses included all covariates, main effects and interaction of verbal and nonverbal pain expression, and the random slope of verbal pain expression, as determined by a log likelihood ratio test ($X^2(1) = 38.2, p < .0001$). As noted in Table 7, the random intercept of concerned spouse responses was statistically significant, such that on average some patients perceived their spouses to show more concerned responses than others did ($\sigma^2_{u0} = 7.13, p < .05$). Some covariates were significant, and they much improved model fit when they were originally entered.

Both verbal and nonverbal pain expressions arose as significant predictors of concerned responses. As hypothesized, on days when patients verbally expressed more pain, spouses acted more concerned in response ($B = 0.58, SE = 0.11, p < .05$). Counter to
prediction, on days when patients nonverbally showed their pain more, spouses were also perceived as responding in a more concerned way ($B = 0.32, SE = 0.09, p < .05$). The interaction between daily verbal and nonverbal pain expression was statistically significant ($B = 0.51, SE = 0.13, p < .05$). At low levels of verbal pain expression, the relationship between nonverbal pain expression and concerned spouse responses was not significant ($p > .05$). However, on days when patients disclosed much pain verbally, their nonverbal pain expression was significantly associated with more concerned spouse responses ($B = 0.46, SE = 0.10, p < .0001$).

As depicted in Figure 13, on days when patients both showed their pain nonverbally and verbally disclosed more than an average amount, spouses acted most concerned ($M = 10.07, SE = 0.23$). Spouses responded in the least concerned way on days when patients expressed pain neither verbally nor nonverbally ($M = 9.22, SE = 0.24$). Further, on days when patients expressed more verbally and less nonverbally ($M = 9.65, SE = 0.24$), spouses were perceived as slightly more concerned than on days when patients expressed more nonverbally and less verbally ($M = 9.38, SE = 0.24$).

The random slope of verbal pain expressions was statistically significant ($\sigma^2_{u9} = 0.60, p < .05$), suggesting that the relationship between daily verbal pain expression and concerned spouse behavior varied across couples.
Chapter 4

Discussion

Social dynamics represent a central yet understudied element of the pain experience, as described in a recently published seminal review:

[...T]o date we have acquired a substantial understanding of pathologies, injuries, and diseases, as sources of pain, and their impact on the host, both in terms of biology and subjective experience. Nevertheless, the contributions of environmental contexts in which pain is suffered have received relatively less formal study perhaps because it is widely assumed that their explanations (e.g., reinforcement concepts) are well established. Nonetheless, there are many important unanswered questions that would be suitable for formal investigation. (Hadjistavropoulos et al., 2011, p. 3)

Indeed, outside of the operant paradigm that has positioned pain expression and, in particular, nonverbal “pain behavior” as undesirable perpetuators of a solicitous cycle that leads to increased pain and patient disability, little empirical work has investigated the role of pain expression in the dyadic experience of chronic pain (cf. Keefe et al., 2003; Keefe, Dunsmore, & Burnett, 1992). Further, no study in an extensive literature review had examined the independent and interactive effects of verbal and nonverbal pain expression, despite the clear distinctions between the two modes of communication.

In the current study, pain interactions of individuals with osteoarthritis and their spouses were conceptualized as transactions wherein messages are received with varying degrees of clarity and accuracy. When the listener receives the pain message clearly, so long as the relationship is a benevolent one and the receiver does not feel immediate threat, he or she is expected to respond in an empathic, help-oriented way (Goubert et al., 2005). Because nonverbal expression may often be less specific and directive than verbal expression, nonverbal cues may increase sufferers’ risk of failing to communicate their
message or, conversely, frustrate listeners with ambiguous signals. In this dyadic study hypotheses were tested using an innovative design approach of intensive repeated measures that revealed patterns across days.

Findings from the current study showed that verbal pain expression was positively related to empathic and solicitous responses, as predicted. Counter to hypothesis, greater nonverbal expression of pain was related to more empathic and solicitous responses. The interaction of nonverbal and verbal pain expression was significant for the outcome of empathic responses, but manifested in a slightly different way than hypothesized. As expected, the daily relationship between nonverbal pain expression and empathic spouse responses differed according to the amount of verbal pain expression. However, the moderating effect of verbal pain expression on the relationship between nonverbal pain expression and spouse responses was enhancing rather than buffering. That is, when levels of verbal pain expression were high, nonverbal pain expression was positively related to empathic reactions and shared no significant relationship with these responses when verbal pain expression was low. Thus, the two modes of pain expression seemed to wield a synergistic effect, such that high levels of both nonverbal and verbal cues corresponded to the most empathic spouse reactions. Findings for the outcome of solicitous responses were very similar to those for empathic responses but the interaction only trended toward statistical significance.
Hypothesis 1: On Days When Nonverbal Pain Expression is Greater, Spouse Responses are More Punishing and Less Empathic and Solicitous

The potential ambiguity of nonverbal pain expression was predicted to discourage caring spouse behaviors (empathic and solicitous responses) and encourage punishing ones (Hadjistavropoulos et al., 2011). However, this hypothesis was not supported by any of the models. Rather, on days when nonverbal pain expression was greater than average, spouses were more empathic and solicitous. The random slope of nonverbal expression was not statistically significant in any of the models, suggesting that its relationships with empathic and solicitous responses were stable across couples.

Higher ratings of nonverbal pain expression may merely indicate that the spouse has perceived some indication of pain and is likely to respond by providing emotional and instrumental support, as is expected from individuals who share a close relationship with the pain sufferer and who feel no immediate threat to their own well-being (Goubert et al., 2005). On a related note, it is important to keep in mind that pain expression and spouse responses were measured on the same day. Though spouses reported greater negative affect on days when they perceived more nonverbal pain expression from patients ($r = .19$, $p < .0001$), this state did not translate to responding in more punishing ways. This finding contradicts work that has shown destructive patterns related to pain behavior. For instance, Stephens and colleagues (2006) found that more frequent nonverbal pain displays of osteoarthritis patients were related to more critical spouse attitudes. Perhaps couple-level characteristics such as overall marital satisfaction serve to protect couples from these negative patterns, or maybe deleterious effects of high nonverbal expression must accumulate across multiple days to become apparent. Future studies should examine
these questions with a sample more diverse in marital satisfaction levels and with lagged analyses.

**Hypothesis 2: On Days When Verbal Pain Expression is Greater, Spouse Responses are Less Punishing and More Empathic and Solicitous**

Daily verbal pain expression was expected to encourage positive and diminish negative spouse responses insofar as verbal cues are likely to deliver a precise message to listening spouses and elicit predictable, benevolent reactions. All models except that of punishing responses supported this hypothesis, plausibly because the punishing response scale suffered from a considerable floor effect. Thus, according to a pain communication framework, nonverbal and verbal cues alike communicated pain to spouses in a way that recruited positive responses. Significant random slopes indicated that the strength of the relationship between verbal pain expression and all spouse responses differed across couples, such that expression and response were more tightly linked in some couples than in others.

This finding runs contrary to the social support deterioration model, which suggests that as individuals continue to suffer from chronic stressors, support from others wanes (Kaniasty & Norris, 1993; Kelly & McKillop, 1996). Stephens and colleagues (2006) partially corroborated the positive relationship between female osteoarthritis patients’ verbal pain disclosure and husband emotional support. The positive main effect of disclosure on husbands’ emotional support was qualified by an interaction, wherein wives with severe pain who reported disclosing much of that pain to their husbands benefitted less in terms of emotional support than did those who suffered from weaker pain and disclosed very much. Even so, wives with high levels of pain who disclosed frequently still
enjoyed greater emotional support than wives who disclosed less frequently. Because wives provided all three reports (pain severity, disclosure level, and spouse emotional support), effects may have been skewed by reporting biases, especially for those experiencing severe pain.

Future analyses should consider years-from-diagnosis as a moderator that may explain variation in the effect of verbal pain expression across dyads. Couples longer from diagnosis may exhibit less support and more punishing behaviors than those more recently diagnosed. Also, lagged effects may reveal a deterioration of support across consecutive days of high verbal pain expression.

**Hypothesis 3: On Days When Verbal Pain Expression is High, the Relationships between Nonverbal Pain Expression and Spouse Responses are Weakened**

The pain communication framework (Hadjistavropoulos et al., 2011) posits that the clearest messages are most likely to be transacted and met, in turn, with benevolent responses. Therefore, it was hypothesized that verbal pain expression would counteract any negative effect induced by potentially nebulous nonverbal pain expression. However, a buffering relationship was not observed in the current study, as nonverbal pain expression was related to greater empathic and solicitous responses, and was unrelated to spouse punishing responses. Nevertheless, the significant interaction for empathic responses and trend for solicitous behaviors were consistent with Hypothesis 3 and with the principles of the pain communication framework. The random slope of these interactions did not reach statistical significance, suggesting that the pattern did not vary across couples.

Tests of Hypothesis 3 revealed an enhancing effect of verbal pain expression, such that on days when patients verbally expressed much pain, greater nonverbal expression was
associated with more empathic and solicitous responses. On days when patients did not express their pain much verbally, variations in nonverbal expression did not relate significantly to empathic responses and shared a marginally significant positive relationship with solicitous responses. Hence, rather than neutralizing a negative effect, verbal expression seemed to make a null association positive. This finding supports the notion that in the absence of verbal clarifications of pain, which may describe the quality of pain in a way that transacts the appropriate message and elicits a desired response, nonverbal cues are not reliably answered with more empathic reactions. If the trending relationship between nonverbal pain expression and solicitous responses in the presence of little verbal pain expression reflects a real phenomenon rather than a statistical artifact, solicitous responses may be more sensitive to the influence of nonverbal pain expression than empathic behaviors seem to be (cf. Craig, Versloot, Goubert, Vervoort, & Crombez, 2010).

The proposed buffering hypothesis did not speak directly to the relationship between verbal expression and spouse responses in the presence of varying levels of nonverbal expression. Nevertheless, Figures 11 and 12 show that verbal pain expression alone did not recruit the most empathic and solicitous responses. Rather, high levels of both verbal and nonverbal pain expression encouraged spouses to act most empathically and solicitously. This finding supports the pain communication framework in that, together, verbal and nonverbal expressions of pain formed a consonant message that was transacted most successfully to spouses, encouraging benevolent, help-oriented responses.

The interaction between verbal and nonverbal pain expression at the daily level represents a novel and informative addition to the literature. The overarching pain
communication model acknowledges distinctions in the nature of nonverbal expression as automatic, uninhibited, and possibly more difficult to decode, and verbal expression as requiring more complex, executive resources (Hadjistavropoulos & Craig, 2002). However, the implications of their daily dynamics in the context of spouse responses to this point have remained unexplored. The current study speaks to not only the interplay between modes of pain communication, but also a baseline time course in which these expression-response exchanges transpire.

Further, the numerous covariates included in the models help to rule out alternative explanations such as general pain perceptions, negative affect, and marital quality. Patients’ experience of pain was expected to function as an interpretive frame, coloring patient perceptions of spouse responses, and spouses’ judgment of the pain should have been related to their reports of patient pain expression. End-of-day negative affect of both patient and spouse was expected to account for any negative response biases in the reporting of patient pain expression and spouse responses, as recent negative emotion may provide a context for negative interpretation of other events (Marco & Suls, 1993). Also, relationship quality has been strongly established as a generalized lens through which other marital interactions are viewed, (Kiecolt-Glaser & Newton, 2001; Turk et al., 1992). Including these factors as covariates provided more confidence that verbal and nonverbal pain expression are unique contributors to variation in day-to-day spouse responses.

**Punishing responses.** The interaction between nonverbal and verbal pain expression for the outcome of punishing responses was non-significant likely because of the large number of parameters and small amount of variance in punishing responses. In addition,
perhaps the high marital satisfaction of the current sample protected patients from spikes in spouses’ punishing behavior.

The Value of Concerned Responses

Items from empathic and solicitous response scales, which correlated highly at the within-person level ($r = .70, p < .001$), were summed to create a single measure that was labeled “concerned responses.” Results from the concerned response model mirrored the findings for empathic responses exactly. That is, both main effects were present, such that on days when patients expressed more pain either verbally or nonverbally, spouses reacted in a more concerned way than on days when patients expressed less. Also, when patients expressed much pain verbally, greater nonverbal pain expression predicted higher levels of spouse concern, whereas nonverbal pain expression was unrelated to spouse concern when patients verbally disclosed little pain.

Though these findings are similar to those for empathic responses, concerned reactions represent a sound methodological and conceptual contribution to the literature. On a methodological level, no precedent has been established for studying spouse responses to pain at the daily level, and the multilevel exploratory factor analysis performed for all three spouse response scales revealed a two-factor solution as the simplest for both within- and between-person levels—suggesting that items thought to be empathic and solicitous clustered into a single factor. Further, the combined scale offered additional psychometric benefit in its greater range and, therefore, higher potential for capturing meaningful changes in concerned spouse responses across days.

On a conceptual level, because empathic and solicitous responses were both thought to be supportive and benevolent in nature, they were hypothesized to relate to pain
expressions in identical ways. Thus, concerned responses provided a more parsimonious construct for examining expression-response exchanges. Further, the distinctions that do exist between empathic and solicitous behavior were not directly relevant to the current study. Solicitous responses have historically been considered special in the operant relationship they share with classically described “pain behaviors.” These types of overzealous responses have been assumed to perpetuate cycles of pain display and eventual increases in physical disability. Therefore, solicitous and empathic responses differ in the ways they each relate to later disability, and not necessarily as outcomes of pain expression. Another important distinction between solicitous and empathic responses lies in the nature of the support that is offered. Solicitous items tap primarily into instrumental offers of support (e.g., taking over tasks, encouraging rest), whereas empathic responses are oriented toward emotional support (e.g., giving undivided attention, showing affection in response to pain). Though these differences are interesting and may very well play into the dynamics of patient-spouse interaction (e.g., in need-response matching; Cutrona, Shaffer, Wesner, & Gardner, 2007), they were not differentiated in hypotheses regarding the predictive power of verbal and nonverbal pain expression.

**Novelty of the Daily Approach**

Theories about the role of the social environment in chronic pain have been developed and tested by characterizing differences between people. However, data gathered across multiple days from numerous couples can reveal not only between-person differences, but also average changes across days and individual variations in these average effects. In the absence of intensive repeated measures, pain expression and spouse responses have
inevitably been conceptualized as static constructs, representing gestalt, retrospective judgments that couples make. In contrast, the current study explored the possibility that verbal and nonverbal pain expression as well as various spouse responses fluctuate on a daily basis. Indeed, almost two thirds of the variability in verbal pain expression and more than half of the variability in nonverbal pain expression were due to within-person, across-day variations. Likewise, more than half of the variance in punishing responses, as well as a third of variability in empathic, solicitous, and concerned responses, was attributed to daily fluctuations. Therefore, characterizing patients as highly verbally expressive or spouses as punishing is a less reasonable postulate than categorizing certain days as ones when a patient is particularly expressive nonverbally or when a spouse acts less empathically. Most previous research has not sought to understand patient-spouse interactions regarding pain at this level (e.g., Lousberg, Schmidt, & Groenman, 1992; Sambo, Howard, Kopelman, Williams, & Fotopoulou, 2010). Beyond appreciating pain expression and spouse responses as dynamic constructs, the approach of intensive repeated measures enables the assessment of frameworks in a new way that more closely approximates the time scale of the actual phenomena and may facilitate the development of theories that are oriented toward not only individual differences, but also intraindividual change.

**Theoretical Implications**

Hypotheses for the current study were informed by a pain communication model and a developmental-contextual perspective. Findings speak to these frameworks as well as to other relevant theoretical orientations.
**Pain communication model.** The current study provides fine-grained, true-to-life evidence for the importance of daily pain communication in the lives of chronic pain sufferers in a way that supports and extends the principles of a pain communication perspective. The basic assumption that clearer pain messages are more likely to be transacted and, hence, acted upon in a predictable way was reflected in the data. Furthermore, this study clarified the role of pain communication mode by demonstrating the various conditions in which verbal and nonverbal moves encourage and discourage empathic and punishing spouse behaviors. The most empathic, solicitous, and concerned responses were elicited on days when patients expressed pain both verbally and nonverbally—suggesting that a consistent message was most amenable to receiving support. Further, on days when patients communicated their pain nonverbally but less so verbally, spouses were less empathic, solicitous, and concerned, as well as more punishing, indicating that more vague pain signals were not transacted clearly enough to elicit benevolent responses. The importance of congruence between verbal and nonverbal channels is compatible with the pain communication model but was not hypothesized or articulated by previous work. The current study provided a particularly strong test of pain communication transaction because reports of pain expression and spouse responses were collected from the opposite partner—that is, spouses reported on patient pain expression and patients reported on spouse responses.

**Developmental-contextual model.** The current study also offers a vibrant example of the dyadic process of coping that Berg and Upchurch (2007) describe in their developmental-contextual model of chronic illness. According to this model, couples facing chronic illness establish joint cycles of influence, wherein reciprocally related patient and
spouse illness appraisals give way to specific coping strategies, such as collaborative or controlling behaviors. The current study gives empirical credence to the inextricable link between the experience of chronic pain and the dyadic context. Pain expression reported by spouses, which may be conceptualized as illness appraisals of the patient, and spouse responses reported by the patient, which may be considered coping strategies of the spouse, covary on a daily basis. Future research from the larger study may seek to answer whether couples at different stages of osteoarthritis vary in these expression-response patterns or if there is some evidence of systematic change in the daily patterns of expression and response.

**Social support deterioration model.** In general, the findings of this study contradicted the principles of support deterioration, which purports that for individuals experiencing chronic stressors, support from others depletes over time (Kaniasty & Norris, 1993; Kelley & McKillop, 1996). Revenson (1994) posited that spouses may tire from continual needs of individuals with arthritis, growing wary of apparently unsuccessful attempts to help remedy the ailing spouse’s condition. Stephens and colleagues (2006) found support for this theory when they investigated the verbal pain disclosure and nonverbal behavior of female osteoarthritis patients and the critical attitudes and emotional support of their husbands.

In the current study, daily spouse responses reflected patterns of robust spouse support, with punishing responses low and empathic and solicitous response averages lying just below the middle of the scales with great variability in both directions. Indeed, empathic and solicitous responses were often high despite the fact that the average time from diagnosis was 12 years, giving spouses much opportunity to tire of providing support.
Further, it was on days when patients expressed pain both verbally and nonverbally that spouses were most empathic and concerned, suggesting that more expression translates to more benevolent reactions— that the taxing of spouses is not apparent at the daily level.

**Limitations**

Despite the useful and informative implications, the current study includes a number of limitations. First, the intensive repeated measures collected daily represents a considerable improvement relative to previous work in the area of pain communication. Nevertheless, actual expression-response exchanges more likely happen on a second-to-second basis rather than on a daily scale. Future research should seek to approximate this metric even more closely. Next, since spouse behaviors were framed as responses they were often discussed in terms of being evoked by pain expression modalities. However, establishing temporal causality was not possible in these data given the same-day nature of the analyses. Also, this sample was overall very maritally satisfied and had been coping with the diagnosis for many years on average. It would be interesting to account for any differences in expression-response patterns in couples who are less satisfied in the relationship or less accustomed to dealing with the illness together.

**Conclusion**

By exploring daily pain expression and spouse responses of couples facing the chronic pain of one partner, the current study answered calls for elucidating the environmental context of the pain experience (Hadjistavropoulos et al., 2011) and the dyadic nature of chronic illness (Berg & Upchurch, 2007). Intricacies of pain communication were examined in a way that revealed a compelling interplay between modes of expression, important for many theories of chronic pain and social support. Future research should
address the role of spouse responses in the prediction of later patient disability and should also investigate more closely the development of these processes across the course of the illness.
References


Appendix

SAS Code for Final Multilevel Models

title 'punishing responses';
proc mixed data=hdfs523.eodmerge method=reml covtest;
class dyad studyday;
where occ=3 and flag4=0 and sp_flag4=0 and studyday<23;
model pun_resp=sp_describe_c sp_show_c na_c sp_na_c sp_overall_c overall_c
sp_tense_c sp_enjoy_c tense_c enjoy_c sp_describe_c*sp_show_c/solution;
random intercept sp_describe_c/ type=vc subject=dyad;
run;

title 'empathic responses';
proc mixed data=hdfs523.eodmerge method=reml covtest;
class dyad studyday;
where occ=3 and flag4=0 and sp_flag4=0 and studyday<23;
model em_resp=sp_describe_c sp_show_c na_c sp_na_c sp_overall_c overall_c
sp_tense_c sp_enjoy_c tense_c enjoy_c sp_describe_c*sp_show_c/solution;
random intercept sp_describe_c/ type=vc subject=dyad;
estimate 'average nonverbal effect' sp_show_c 1;
estimate 'nonverbal effect at high verbal' sp_show_c 1 sp_describe_c*sp_show_c .4818911;
estimate 'nonverbal effect at low verbal' sp_show_c 1 sp_describe_c*sp_show_c -.4818911;
run;

title 'solicitous responses';
proc mixed data=hdfs523.eodmerge method=reml covtest;
class dyad studyday;
where occ=3 and flag4=0 and sp_flag4=0 and studyday<23;
model so_resp=sp_describe_c sp_show_c na_c sp_na_c sp_overall_c overall_c
sp_tense_c sp_enjoy_c tense_c enjoy_c sp_describe_c*sp_show_c/solution;
random intercept sp_describe_c/ type=vc subject=dyad;
estimate 'average nonverbal effect' sp_show_c 1;
estimate 'nonverbal effect at high verbal' sp_show_c 1 sp_describe_c*sp_show_c .4818911;
estimate 'nonverbal effect at low verbal' sp_show_c 1 sp_describe_c*sp_show_c -.4818911;
run;

title 'concerned responses';
proc mixed data=hdfs523.eodmerge method=reml covtest;
class dyad studyday;
where occ=3 and flag4=0 and sp_flag4=0 and studyday<23;
model care_resp=sp_describe_c sp_show_c na_c sp_na_c sp_overall_c overall_c
sp_tense_c sp_enjoy_c tense_c enjoy_c sp_describe_c*sp_show_c/solution;
random intercept sp_describe_c/ type=vc subject=dyad;
estimate 'average nonverbal effect' sp_show_c 1;
estimate 'nonverbal effect at high verbal' sp_show_c 1 sp_describe_c*sp_show_c .4818911;
estimate 'nonverbal effect at low verbal' sp_show_c 1 sp_describe_c*sp_show_c -.4818911;
run;
Table 1

Demographic Characteristics of Patients and Spouses (N = 144)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients</th>
<th>Spouses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD) or N%</td>
<td>M (SD) or N%</td>
</tr>
<tr>
<td>Age</td>
<td>65.6 (9.8)</td>
<td>65.3 (11.5)</td>
</tr>
<tr>
<td>Male gender</td>
<td>43%</td>
<td>58%</td>
</tr>
<tr>
<td>White race</td>
<td>88%</td>
<td>86%</td>
</tr>
<tr>
<td>Years of education</td>
<td>16.1 (2.0)</td>
<td>15.9 (2.1)</td>
</tr>
<tr>
<td>Full-time employment</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Duration of knee OA (years)</td>
<td>12.6 (11.3)</td>
<td></td>
</tr>
<tr>
<td>Household income</td>
<td></td>
<td>$40,000-59,000</td>
</tr>
<tr>
<td>Years married/in relationship</td>
<td></td>
<td>34.3 (16.6)</td>
</tr>
<tr>
<td>Marital satisfaction</td>
<td>39.61 (6.26)</td>
<td>38.94 (6.47)</td>
</tr>
</tbody>
</table>

Note. Full-time employment status was defined as typically working 30 hours or more per week. Marital satisfaction was assessed with the 10-item dyadic satisfaction subscale of the Dyadic Adjustment Scale, whose scores range 0 - 50 (Spanier, 1976). The current sample was compared on all of the above characteristics to the couples who were not included in analyses using independent samples t-tests. Couples were not significantly different except in gender and income. The current sample included significantly fewer female patients (t(8.6) = -2.32, p < .05) and couples with higher annual income (t(150) = 2.37, p < .05). OA = osteoarthritis. M= mean. SD= standard deviation.
Table 2

*Multilevel Exploratory Factor Analysis of Spouse Responses to Patient Pain*

<table>
<thead>
<tr>
<th></th>
<th>1 Factor Solution</th>
<th>2 Factor Solution</th>
<th>3 Factor Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within-couple</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Took over</td>
<td>0.50</td>
<td>0.50</td>
<td>0.63</td>
</tr>
<tr>
<td>2. Ignored</td>
<td>-0.15</td>
<td>-0.13</td>
<td>-0.13</td>
</tr>
<tr>
<td>3. Asked to rest</td>
<td>0.54</td>
<td>0.54</td>
<td>0.53</td>
</tr>
<tr>
<td>4. Showed affection</td>
<td>0.62</td>
<td>0.62</td>
<td>0.46</td>
</tr>
<tr>
<td>5. Gave food or drink</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>6. Got frustrated</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>7. Knew feelings</td>
<td>0.58</td>
<td>0.58</td>
<td>0.38</td>
</tr>
<tr>
<td>8. Paid attention</td>
<td>0.67</td>
<td>0.67</td>
<td>0.50</td>
</tr>
<tr>
<td>9. Became irritated</td>
<td>-0.10</td>
<td>-0.08</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.81</td>
<td>0.82</td>
</tr>
<tr>
<td><strong>Between-couple</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Took over</td>
<td>0.68</td>
<td>0.68</td>
<td>0.82</td>
</tr>
<tr>
<td>2. Ignored</td>
<td>-0.23</td>
<td>-0.24</td>
<td>-0.16</td>
</tr>
<tr>
<td>3. Asked to rest</td>
<td>0.82</td>
<td>0.82</td>
<td>0.93</td>
</tr>
<tr>
<td>4. Showed affection</td>
<td>0.97</td>
<td>0.97</td>
<td>0.84</td>
</tr>
<tr>
<td>5. Gave food or drink</td>
<td>0.79</td>
<td>0.80</td>
<td>0.88</td>
</tr>
<tr>
<td>6. Got frustrated</td>
<td>-0.04</td>
<td>-0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>7. Knew feelings</td>
<td>0.86</td>
<td>0.86</td>
<td>0.77</td>
</tr>
<tr>
<td>8. Paid attention</td>
<td>0.86</td>
<td>0.96</td>
<td>0.79</td>
</tr>
<tr>
<td>9. Became irritated</td>
<td>-0.02</td>
<td>-0.02</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>RMSEA</strong></td>
<td>0.09</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>CFI</strong></td>
<td>0.73</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td><strong>X² (df)</strong></td>
<td>1329.8 (54)</td>
<td>223.6 (38)</td>
<td>36.9 (24)</td>
</tr>
</tbody>
</table>

*Note.* All items reflect patient perceptions of spouse behaviors at the end of each of the 22 study days on a scale of 1 (not at all) to 3 (very much). Factor loadings were extracted from the factor structure and, thus, reflect unrotated solutions. That is, they represent independent, non-overlapping allocations of variance to each factor. RMSEA = root mean squared error of approximation; lower than .06 indicates good fit. CFI = Confirmatory Fit Index; higher than .95 indicates good fit. X² (df) = Chi-square goodness-of-fit test (degrees of freedom). All three models were statistically significant—a strict indicator of misfit to the data. Chi-square difference tests were performed. The second solution significantly improved fit to the data from the first solution, and the three-factor solution reflected a significantly better fit than the second.
Table 3

Means, Standard Deviations, and Intercorrelations of Predictors, Outcomes, and Covariates

<table>
<thead>
<tr>
<th>Predictors, Outcomes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verbal Expression</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.58 (0.61)</td>
</tr>
<tr>
<td>2. Nonverbal Expression</td>
<td>.52*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.59 (0.63)</td>
</tr>
<tr>
<td>3. Empathic Response</td>
<td>.32*</td>
<td>.21*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.17 (1.87)</td>
</tr>
<tr>
<td>4. Solicitous Response</td>
<td>.29*</td>
<td>.27*</td>
<td>.70*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.48 (1.64)</td>
</tr>
<tr>
<td>5. Punishing Response</td>
<td>.02</td>
<td>.10*</td>
<td>-.14*</td>
<td>-.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>3.25 (0.69)</td>
</tr>
<tr>
<td>6. Concerned Response</td>
<td>.27*</td>
<td>.22*</td>
<td>.79*</td>
<td>.77*</td>
<td>-.08*</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.61 (3.22)</td>
</tr>
<tr>
<td>Covariates</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7. Pt Pain</td>
<td>.23*</td>
<td>.22*</td>
<td>.25*</td>
<td>.28*</td>
<td>.08*</td>
<td>.27*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.52 (0.66)</td>
</tr>
<tr>
<td>8. Pt Pain (Sp)</td>
<td>.55*</td>
<td>.60*</td>
<td>.27*</td>
<td>.29*</td>
<td>.10*</td>
<td>.28*</td>
<td>.35*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.36 (0.84)</td>
</tr>
<tr>
<td>9. Pt Negative Affect</td>
<td>.01</td>
<td>.03</td>
<td>-.00</td>
<td>.01</td>
<td>.27*</td>
<td>.03</td>
<td>.17*</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.43 (4.33)</td>
</tr>
<tr>
<td>10. Sp Negative Affect</td>
<td>.12*</td>
<td>.19*</td>
<td>-.02</td>
<td>.01</td>
<td>.13*</td>
<td>-.01</td>
<td>.07</td>
<td>.14*</td>
<td>.14*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.07 (4.19)</td>
</tr>
<tr>
<td>11. Pt Tension</td>
<td>.03</td>
<td>.10*</td>
<td>-.12*</td>
<td>-.02</td>
<td>.36*</td>
<td>-.03</td>
<td>.09*</td>
<td>.07</td>
<td>.25*</td>
<td>.26*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.21 (0.46)</td>
</tr>
<tr>
<td>12. Pt Enjoyment</td>
<td>.12*</td>
<td>.01</td>
<td>.42*</td>
<td>.30*</td>
<td>-.19*</td>
<td>.34*</td>
<td>.01</td>
<td>.04</td>
<td>-.22*</td>
<td>-.13*</td>
<td>-.34*</td>
<td></td>
<td></td>
<td></td>
<td>2.44 (0.61)</td>
</tr>
<tr>
<td>13. Sp Tension</td>
<td>.13*</td>
<td>.23*</td>
<td>-.01</td>
<td>.05</td>
<td>.16*</td>
<td>-.02</td>
<td>.05</td>
<td>.16*</td>
<td>.11*</td>
<td>.38*</td>
<td>.33*</td>
<td>-.16*</td>
<td></td>
<td></td>
<td>1.23 (0.46)</td>
</tr>
<tr>
<td>14. Sp Enjoyment</td>
<td>.03*</td>
<td>-.01</td>
<td>.19*</td>
<td>.11*</td>
<td>-.12*</td>
<td>.13*</td>
<td>-.02</td>
<td>-.01</td>
<td>-.12*</td>
<td>-.18*</td>
<td>-.19*</td>
<td>.30*</td>
<td>-.25*</td>
<td></td>
<td>2.42 (0.57)</td>
</tr>
</tbody>
</table>

Note. Means and standard deviations summarize raw scores at the daily level. Correlations reflect within-couple, across-day relationships. Pt = patient. Sp = spouse. (Sp) = spouse report. M = mean. SD = standard deviation. The potential number of observations reached up to 3168 (144 couples across 22 days), * p < .0001.
## Table 4
### Multilevel Models of Punishing Spouse Responses

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Empty</th>
<th>Covariates</th>
<th>Pain Expressions</th>
<th>Interaction</th>
<th>Random, Verbal</th>
<th>Random, Nonverbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>3.22* (0.03)</td>
<td>3.23* (0.03)</td>
<td>3.23* (0.03)</td>
<td>3.23* (0.04)</td>
<td>3.23* (0.04)</td>
<td>3.23* (0.04)</td>
</tr>
<tr>
<td>Patient pain (pt), $\gamma_{10}$</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
</tr>
<tr>
<td>Patient pain (sp), $\gamma_{20}$</td>
<td>0.04 (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
<td>0.05* (0.02)</td>
</tr>
<tr>
<td>Pt negative affect, $\gamma_{30}$</td>
<td>0.02* (0.00)</td>
<td>0.02* (0.00)</td>
<td>0.02* (0.01)</td>
<td>0.02* (0.00)</td>
<td>0.02* (0.01)</td>
<td></td>
</tr>
<tr>
<td>Sp negative affect, $\gamma_{40}$</td>
<td>-0.01* (0.00)</td>
<td>-0.01* (0.00)</td>
<td>-0.01* (0.00)</td>
<td>-0.01* (0.00)</td>
<td>-0.01* (0.00)</td>
<td></td>
</tr>
<tr>
<td>Pt marital tension, $\gamma_{50}$</td>
<td>0.41* (0.03)</td>
<td>0.31* (0.03)</td>
<td>0.31* (0.03)</td>
<td>0.32* (0.03)</td>
<td>0.32* (0.03)</td>
<td></td>
</tr>
<tr>
<td>Pt marital enjoyment, $\gamma_{60}$</td>
<td>-0.06* (0.03)</td>
<td>-0.06* (0.03)</td>
<td>-0.06* (0.03)</td>
<td>-0.06* (0.03)</td>
<td>-0.06* (0.03)</td>
<td></td>
</tr>
<tr>
<td>Sp marital tension, $\gamma_{70}$</td>
<td>0.03 (0.03)</td>
<td>0.03 (0.03)</td>
<td>0.03 (0.03)</td>
<td>0.04 (0.03)</td>
<td>0.04 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Sp marital enjoyment, $\gamma_{80}$</td>
<td>-0.05* (0.03)</td>
<td>-0.05* (0.03)</td>
<td>-0.05* (0.03)</td>
<td>-0.05* (0.03)</td>
<td>-0.05* (0.03)</td>
<td></td>
</tr>
<tr>
<td>Verbal pain expression, $\gamma_{90}$</td>
<td>-0.04 (0.02)</td>
<td>-0.03 (0.02)</td>
<td>-0.04 (0.03)</td>
<td>-0.03 (0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonverbal pain expression, $\gamma_{100}$</td>
<td>0.01 (0.03)</td>
<td>-0.02 (0.03)</td>
<td>0.02 (0.03)</td>
<td>0.01 (0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal X Nonverbal, $\gamma_{110}$</td>
<td>-0.06 (0.04)</td>
<td>-0.06 (0.04)</td>
<td>-0.06 (0.04)</td>
<td>-0.06 (0.04)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Random effects

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Empty</th>
<th>Covariates</th>
<th>Pain Expressions</th>
<th>Interaction</th>
<th>Random, Verbal</th>
<th>Random, Nonverbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\sigma^2_{u0}$</td>
<td>0.15* (0.02)</td>
<td>0.16* (0.02)</td>
<td>0.16* (0.02)</td>
<td>0.16* (0.02)</td>
<td>0.16* (0.02)</td>
<td>0.16* (0.02)</td>
</tr>
<tr>
<td>Verbal slope, $\sigma^2_{u9}$</td>
<td>0.02* (0.01)</td>
<td>0.02* (0.01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonverbal slope, $\sigma^2_{u10}$</td>
<td>0.01 (0.01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual variance, $\sigma^2_e$</td>
<td>0.24* (0.01)</td>
<td>0.22* (0.01)</td>
<td>0.22* (0.01)</td>
<td>0.22* (0.01)</td>
<td>0.21* (0.01)</td>
<td>0.21* (0.01)</td>
</tr>
<tr>
<td>$-2LL$</td>
<td>3602</td>
<td>3340</td>
<td>3345</td>
<td>3348</td>
<td>3344</td>
<td>3343</td>
</tr>
<tr>
<td>$AIC$</td>
<td>3606</td>
<td>3344</td>
<td>3349</td>
<td>3352</td>
<td>3350</td>
<td>3351</td>
</tr>
</tbody>
</table>

*Note.* Unstandardized estimates and standard errors. Model based on 22 occasions nested within 144 participants for a total of up to 3168 observations. The inclusion of a verbal pain expression random slope improved model fit according to a log likelihood ratio test ($\chi^2(1) = 6.3, p = .011$). However, the nonverbal pain expression random slope did not improve model fit ($\chi^2(1) = 1.1, p > .05$). A random slope for the interaction of verbal and nonverbal pain expressions not shown above also failed to improve model fit ($\chi^2(1) = 0, p > .05$). $AIC$ = Akaike Information Criterion; $-2LL = -2$ Log Likelihood, relative model fit statistics.* $p < .05$. 

\( \chi^2 \)
### Table 5

**Multilevel Models of Empathic Spouse Responses**

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Empty</th>
<th>Covariates</th>
<th>Pain Expressions</th>
<th>Interaction</th>
<th>Random, Verbal</th>
<th>Random, Nonverbal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>5.16* (0.13)</td>
<td>5.16* (0.13)</td>
<td>5.16* (0.13)</td>
<td>5.14* (0.13)</td>
<td>5.13* (0.13)</td>
<td>5.13* (0.13)</td>
</tr>
<tr>
<td>Patient pain (pt), $\gamma_{10}$</td>
<td>0.33* (0.05)</td>
<td>0.29* (0.05)</td>
<td>0.28* (0.05)</td>
<td>0.26* (0.05)</td>
<td>0.26* (0.05)</td>
<td>0.26* (0.05)</td>
</tr>
<tr>
<td>Patient pain (sp), $\gamma_{20}$</td>
<td>0.32* (0.04)</td>
<td>0.12* (0.05)</td>
<td>0.12* (0.05)</td>
<td>0.12* (0.05)</td>
<td>0.11* (0.05)</td>
<td>0.11* (0.05)</td>
</tr>
<tr>
<td>Pt negative affect, $\gamma_{30}$</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.02* (0.01)</td>
<td>-0.02* (0.01)</td>
<td>-0.02* (0.01)</td>
</tr>
<tr>
<td>Sp negative affect, $\gamma_{40}$</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
</tr>
<tr>
<td>Pt marital tension, $\gamma_{50}$</td>
<td>-0.22* (0.07)</td>
<td>-0.25* (0.07)</td>
<td>-0.25* (0.07)</td>
<td>-0.25* (0.07)</td>
<td>-0.25* (0.07)</td>
<td>-0.25* (0.07)</td>
</tr>
<tr>
<td>Pt marital enjoyment, $\gamma_{60}$</td>
<td>0.38* (0.06)</td>
<td>0.35* (0.06)</td>
<td>0.35* (0.06)</td>
<td>0.35* (0.06)</td>
<td>0.35* (0.06)</td>
<td>0.35* (0.06)</td>
</tr>
<tr>
<td>Sp marital tension, $\gamma_{70}$</td>
<td>0.07 (0.07)</td>
<td>0.05 (0.06)</td>
<td>0.05 (0.06)</td>
<td>0.05 (0.06)</td>
<td>0.05 (0.06)</td>
<td>0.06 (0.06)</td>
</tr>
<tr>
<td>Sp marital enjoyment, $\gamma_{80}$</td>
<td>0.19* (0.07)</td>
<td>0.16* (0.06)</td>
<td>0.16* (0.06)</td>
<td>0.15* (0.05)</td>
<td>0.15* (0.05)</td>
<td>0.15* (0.05)</td>
</tr>
<tr>
<td>Verbal pain expression, $\gamma_{90}$</td>
<td>0.37* (0.05)</td>
<td>0.35* (0.05)</td>
<td>0.37* (0.07)</td>
<td>0.36* (0.06)</td>
<td>0.36* (0.06)</td>
<td>0.36* (0.06)</td>
</tr>
<tr>
<td>Nonverbal pain expression, $\gamma_{100}$</td>
<td>0.18* (0.05)</td>
<td>0.16* (0.06)</td>
<td>0.14* (0.06)</td>
<td>0.15* (0.06)</td>
<td>0.15* (0.06)</td>
<td>0.15* (0.06)</td>
</tr>
<tr>
<td>Verbal X Nonverbal, $\gamma_{110}$</td>
<td>0.19* (0.08)</td>
<td>0.17* (0.08)</td>
<td>0.16* (0.08)</td>
<td>0.16† (0.09)</td>
<td>0.16† (0.09)</td>
<td>0.16† (0.09)</td>
</tr>
<tr>
<td><strong>Random effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, $\alpha^2_{u0}$</td>
<td>2.25* (0.28)</td>
<td>2.25* (0.28)</td>
<td>2.27* (0.28)</td>
<td>2.27* (0.28)</td>
<td>2.26* (0.28)</td>
<td>2.26* (0.28)</td>
</tr>
<tr>
<td>Verbal slope, $\alpha^2_{u9}$</td>
<td>0.17* (0.05)</td>
<td>0.17* (0.05)</td>
<td>0.16* (0.05)</td>
<td>0.16* (0.05)</td>
<td>0.16* (0.05)</td>
<td>0.16* (0.05)</td>
</tr>
<tr>
<td>Nonverbal slope, $\alpha^2_{u10}$</td>
<td>0.05 (0.04)</td>
<td>0.05 (0.04)</td>
<td>0.05 (0.04)</td>
<td>0.05 (0.04)</td>
<td>0.05 (0.04)</td>
<td>0.05 (0.04)</td>
</tr>
<tr>
<td>Residual variance, $\sigma^2_e$</td>
<td>1.16* (0.04)</td>
<td>1.04* (0.03)</td>
<td>1.00* (0.03)</td>
<td>1.00* (0.03)</td>
<td>0.95* (0.03)</td>
<td>0.95* (0.03)</td>
</tr>
</tbody>
</table>

$–2LL$ | 7350 | 6942 | 6839 | 6838 | 6812 | 6810 | 6818 | 6818

$AIC$ | 7354 | 6946 | 6843 | 6842 | 6818 | 6818 | 6818 | 6818

**Note.** Unstandardized estimates and standard errors. Model based on 22 occasions nested within 144 participants for a total of up to 3168 observations. The inclusion of a verbal pain expression random slope improved model fit according to a log likelihood ratio test ($X^2(1) = 24.7, p < .0001$). The nonverbal pain expression random slope did not improve model fit ($X^2(1) = 1.9, p > .05$). A random slope for the interaction of verbal and nonverbal pain expressions not shown above also failed to improve model fit ($X^2(1) = 0, p > .05$). $AIC =$ Akaike Information Criterion; $–2LL = –2$ Log Likelihood, relative model fit statistics.* $p < .05$. † $p < .07$.    


Table 6
**Multilevel Models of Solicitous Spouse Responses**

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Empty</th>
<th>Covariates</th>
<th>Pain Expressions</th>
<th>Interaction</th>
<th>Random, Verbal</th>
<th>Random, Nonverbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>4.48* (0.11)</td>
<td>4.47* (0.11)</td>
<td>4.47* (0.11)</td>
<td>4.46* (0.11)</td>
<td>4.45* (0.11)</td>
<td>4.45* (0.11)</td>
</tr>
<tr>
<td>Patient pain (pt), $\gamma_{10}$</td>
<td>0.28* (0.05)</td>
<td>0.25* (0.05)</td>
<td>0.25* (0.05)</td>
<td>0.23* (0.05)</td>
<td>0.23* (0.05)</td>
<td>0.23* (0.05)</td>
</tr>
<tr>
<td>Patient pain (sp), $\gamma_{20}$</td>
<td>0.26* (0.04)</td>
<td>0.10* (0.05)</td>
<td>0.10* (0.05)</td>
<td>0.09* (0.05)</td>
<td>0.09* (0.05)</td>
<td>0.09* (0.05)</td>
</tr>
<tr>
<td>Pt negative affect, $\gamma_{30}$</td>
<td>0.00 (0.01)</td>
<td>0.00 (0.01)</td>
<td>0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
</tr>
<tr>
<td>Sp negative affect, $\gamma_{40}$</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
<td>-0.00 (0.01)</td>
</tr>
<tr>
<td>Pt marital tension, $\gamma_{50}$</td>
<td>-0.21* (0.06)</td>
<td>-0.23* (0.06)</td>
<td>-0.23* (0.06)</td>
<td>-0.22* (0.06)</td>
<td>-0.22* (0.06)</td>
<td>-0.22* (0.06)</td>
</tr>
<tr>
<td>Pt marital enjoyment, $\gamma_{60}$</td>
<td>0.22* (0.06)</td>
<td>0.20* (0.05)</td>
<td>0.20* (0.06)</td>
<td>0.21* (0.05)</td>
<td>0.21* (0.05)</td>
<td>0.21* (0.05)</td>
</tr>
<tr>
<td>Sp marital tension, $\gamma_{70}$</td>
<td>0.06 (0.06)</td>
<td>0.03 (0.06)</td>
<td>0.03 (0.06)</td>
<td>0.03 (0.06)</td>
<td>0.03 (0.06)</td>
<td>0.03 (0.06)</td>
</tr>
<tr>
<td>Sp marital enjoyment, $\gamma_{80}$</td>
<td>0.08 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.05)</td>
</tr>
<tr>
<td>Verbal pain expression, $\gamma_{90}$</td>
<td>0.20* (0.05)</td>
<td>0.19* (0.05)</td>
<td>0.21* (0.06)</td>
<td>0.21* (0.06)</td>
<td>0.20* (0.06)</td>
<td>0.20* (0.06)</td>
</tr>
<tr>
<td>Nonverbal pain expression, $\gamma_{100}$</td>
<td>0.23* (0.05)</td>
<td>0.21* (0.05)</td>
<td>0.19* (0.05)</td>
<td>0.20* (0.05)</td>
<td>0.20* (0.05)</td>
<td>0.20* (0.05)</td>
</tr>
<tr>
<td>Verbal X Nonverbal, $\gamma_{110}$</td>
<td>0.14† (0.08)</td>
<td>0.14† (0.08)</td>
<td>0.13 (0.08)</td>
<td>0.13 (0.08)</td>
<td>0.13 (0.08)</td>
<td>0.13 (0.08)</td>
</tr>
</tbody>
</table>

**Random effects**

| Intercept, $\sigma^2_{u0}$ | 1.75* (0.22) | 1.74* (0.22) | 1.74* (0.22) | 1.74* (0.22) | 1.74* (0.21) | 1.74* (0.21) |
| Verbal slope, $\sigma^2_{u9}$ | 0.17* (0.05) | 0.14* (0.05) | 0.07† (0.05) | 0.07† (0.05) | 0.07† (0.05) | 0.07† (0.05) |
| Nonverbal slope, $\sigma^2_{u10}$ | 0.96* (0.03) | 0.90* (0.03) | 0.88* (0.03) | 0.88* (0.03) | 0.84* (0.03) | 0.83* (0.03) |
| Residual variance, $\sigma^2_e$ | 0.96* (0.03) | 0.90* (0.03) | 0.88* (0.03) | 0.88* (0.03) | 0.84* (0.03) | 0.83* (0.03) |
| $-2LL$ | 6936 | 6926 | 6567 | 6867 | 6536 | 6532 |
| $AIC$ | 6940 | 6930 | 6571 | 6871 | 6542 | 6540 |

**Note.** Unstandardized estimates and standard errors. Model based on 22 occasions nested within 144 participants for a total of up to 3168 observations. The inclusion of a verbal pain expression random slope improved model fit according to a log likelihood ratio test ($X^2(1) = 29.2, p < .0001$). Also, the nonverbal pain expression random slope improved model fit to a marginally significant degree ($X^2(1) = 3.4, p = .065$). A random slope for the interaction of verbal and nonverbal pain expressions not shown above failed to improve model fit ($X^2(1) = 0.2, p > .05$). $AIC =$ Akaike Information Criterion; $-2LL = -2$ Log Likelihood, relative model fit statistics.* $p < .05$, † $p < .07$
Table 7
Multilevel Models of Concerned Spouse Responses

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Empty</th>
<th>Covariates</th>
<th>Pain Expressions</th>
<th>Interaction</th>
<th>Random, Verbal</th>
<th>Random, Nonverbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>9.64* (0.23)</td>
<td>9.61* (0.23)</td>
<td>9.61* (0.23)</td>
<td>9.58* (0.23)</td>
<td>9.58* (0.23)</td>
<td>9.58* (0.23)</td>
</tr>
<tr>
<td>Patient pain (pt), $\gamma_{10}$</td>
<td>0.60* (0.08)</td>
<td>0.53* (0.08)</td>
<td>0.52* (0.08)</td>
<td>0.48* (0.08)</td>
<td>0.48* (0.08)</td>
<td>0.48* (0.08)</td>
</tr>
<tr>
<td>Patient pain (sp), $\gamma_{20}$</td>
<td>0.59* (0.07)</td>
<td>0.22* (0.08)</td>
<td>0.23* (0.08)</td>
<td>0.21* (0.08)</td>
<td>0.21* (0.08)</td>
<td>0.21* (0.08)</td>
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<tr>
<td>Pt negative affect, $\gamma_{30}$</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.02 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.01 (0.01)</td>
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<tr>
<td>Sp negative affect, $\gamma_{40}$</td>
<td>0.00 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
</tr>
<tr>
<td>Pt marital tension, $\gamma_{50}$</td>
<td>-0.43* (0.11)</td>
<td>-0.48* (0.11)</td>
<td>-0.48* (0.11)</td>
<td>-0.47* (0.11)</td>
<td>-0.47* (0.11)</td>
<td>-0.47* (0.11)</td>
</tr>
<tr>
<td>Pt marital enjoyment, $\gamma_{60}$</td>
<td>0.60* (0.10)</td>
<td>0.54* (0.10)</td>
<td>0.54* (0.10)</td>
<td>0.56* (0.09)</td>
<td>0.55* (0.09)</td>
<td>0.55* (0.09)</td>
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<tr>
<td>Sp marital tension, $\gamma_{70}$</td>
<td>0.13 (0.11)</td>
<td>0.09 (0.11)</td>
<td>0.08 (0.11)</td>
<td>0.09 (0.10)</td>
<td>0.09 (0.10)</td>
<td>0.09 (0.10)</td>
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<tr>
<td>Sp marital enjoyment, $\gamma_{80}$</td>
<td>0.29* (0.09)</td>
<td>0.23* (0.09)</td>
<td>0.22* (0.09)</td>
<td>0.21* (0.09)</td>
<td>0.21* (0.09)</td>
<td>0.21* (0.09)</td>
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<tr>
<td>Verbal pain expression, $\gamma_{90}$</td>
<td>0.58* (0.09)</td>
<td>0.55* (0.09)</td>
<td>0.58* (0.11)</td>
<td>0.57* (0.11)</td>
<td>0.57* (0.11)</td>
<td>0.57* (0.11)</td>
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<tr>
<td>Nonverbal pain expression, $\gamma_{100}$</td>
<td>0.40* (0.09)</td>
<td>0.36* (0.09)</td>
<td>0.32* (0.09)</td>
<td>0.34* (0.10)</td>
<td>0.34* (0.10)</td>
<td>0.34* (0.10)</td>
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<tr>
<td>Verbal X Nonverbal, $\gamma_{110}$</td>
<td>0.35* (0.13)</td>
<td>0.29* (0.14)</td>
<td>0.27* (0.14)</td>
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<tr>
<td>Random effects</td>
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<tr>
<td>Intercept, $\sigma^2_{u0}$</td>
<td>7.17* (0.88)</td>
<td>7.13* (0.88)</td>
<td>7.16* (0.88)</td>
<td>7.13* (0.87)</td>
<td>7.13* (0.87)</td>
<td>7.13* (0.87)</td>
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<tr>
<td>Verbal slope, $\sigma^2_{u9}$</td>
<td>0.60* (0.16)</td>
<td>0.55* (0.16)</td>
<td>0.55* (0.16)</td>
<td>0.55* (0.16)</td>
<td>0.55* (0.16)</td>
<td>0.55* (0.16)</td>
</tr>
<tr>
<td>Nonverbal slope, $\sigma^2_{u10}$</td>
<td>0.14 (0.13)</td>
<td>0.14 (0.13)</td>
<td>0.14 (0.13)</td>
<td>0.14 (0.13)</td>
<td>0.14 (0.13)</td>
<td>0.14 (0.13)</td>
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<tr>
<td>Residual variance, $\sigma^2_\epsilon$</td>
<td>3.15* (0.09)</td>
<td>2.80* (0.09)</td>
<td>2.69* (0.08)</td>
<td>2.68* (0.08)</td>
<td>2.54* (0.08)</td>
<td>2.51* (0.08)</td>
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<tr>
<td>$-2LL$</td>
<td>9650</td>
<td>9150</td>
<td>9041</td>
<td>9036</td>
<td>8998</td>
<td>8997</td>
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<tr>
<td>$AIC$</td>
<td>9654</td>
<td>9154</td>
<td>9045</td>
<td>9040</td>
<td>9004</td>
<td>9005</td>
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</tbody>
</table>

Note. Unstandardized estimates and standard errors. Model based on 22 occasions nested within 144 participants for a total of up to 3168 observations. The inclusion of a verbal pain expression random slope improved model fit according to a log likelihood ratio test ($\chi^2(1) = 38.2$, $p < .0001$). The nonverbal pain expression random slope did not improve model fit ($\chi^2(1) = 1.6$, $p > .05$). A random slope for the interaction of verbal and nonverbal pain expressions not shown above failed to improve model fit ($\chi^2(1) = 0.1$, $p > .05$). $AIC$ = Akaike Information Criterion; $-2LL$ = $-2$ Log Likelihood, relative model fit statistics.* $p < .05$. † $p < .07$. 
Figure 1. Between- and within-person variability in patient verbal pain expression.
Figure 2. Between- and within-person variability in patient nonverbal pain expression.
Figure 3. Daily variability in raw scores of spouse punishing responses as reported by a random subset of 50 patients across the 22 consecutive study days. From the graph, it is apparent that most spouses remained low in punishing responses for the duration of the study, with only a few exhibiting occasional spikes in punishing behavior. Colors are used to differentiate individual lines.
Figure 4. Between- and within-person variability in punishing spouse responses.
Figure 5. Daily variability in raw scores of spouse empathic responses as reported by a random subset of 50 patients across the 22 consecutive study days. Unlike punishing responses, empathic responses spanned the entire scale throughout the study period. Colors differentiate individual lines.
Figure 6. Between- and within-person variability in empathic spouse responses.
Figure 7. Daily variability in raw scores of spouse solicitous responses as reported by a random subset of 50 patients across the 22 consecutive study days. Spouses varied across most of the scale over the course of the study period, with some demonstrating more static patterns and others showing more dynamic changes in their solicitousness. Colors were used to differentiate individual lines.
Figure 8. Between- and within-person variability in solicitous spouse responses.
Figure 9. Daily variability in raw scores of concerned spouse responses as reported by a random subset of 50 patients across the 22 consecutive study days. Most spouses did not reach the highest level of concerned responses during the study period. Colors were used to differentiate individual lines.
Figure 10. Between- and within-person variability in concerned spouse responses.
Figure 11. Interaction of verbal and nonverbal pain expression on empathic spouse responses. Low indicates one standard deviation below the within-person mean, and high denotes one standard deviation above the within-person mean.
Figure 12. Interaction of verbal and nonverbal pain expressions on solicitous spouse responses. *Low* indicates one standard deviation below the within-person mean, and *high* denotes one standard deviation above the within-person mean.
Figure 13. Interaction of verbal and nonverbal pain expressions on concerned spouse responses. Low indicates one standard deviation below the within-person mean, and high denotes one standard deviation above the within-person mean.