**MARITAL QUALITY AND PLASMA LEVELS OF OXYTOCIN
AND VASOPRESSIN**

MASTER'S THESIS

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ABSTRACT

In animal studies the nanopeptides oxytocin (OT) and vasopressin (AVP) have been associated with social bonding. In humans, OT plasma levels appear to covary with perceptions of relationship quality. To investigate the relationships between behavioral indicators of marital quality and OT and AVP plasma levels, 37 couples were admitted for a 24-hour visit at the research center. Couples participated in a structured social support interaction task and completed self-report questionnaires of marital quality. Plasma OT and AVP were assayed using enzyme immunoassays. Positive behaviors during the marital interaction task were positively related to OT plasma levels, while both observed and self-reported negative behaviors were negatively associated with AVP plasma levels. These results provide evidence that marital quality is positively related to both OT and AVP plasma levels in humans.

Dedicated to my family

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CHAPTER 1

INTRODUCTION

Survival and reproduction of *homo sapiens sapiens* are tightly related to his capacity to form and maintain interpersonal relationships. Strong evolutionary pressures have thus likely shaped the formation of a neurobiological system regulating social interactions (Dunbar & Shultz, 2007). Little is known about the neurobiology of attachment in humans, but animal studies suggest that two related hormones, oxytocin (OT) and arginine vasopressin (AVP), may be involved in the regulation of social behaviors.

Biology of OT and AVP

Oxytocin and AVP are peptide hormones, differing in chemical composition only by the position of two amino acids. These polypeptides are synthesized in the supraoptic and paraventricular nuclei of the hypothalamus and subsequently stored in the posterior pituitary, where they can be released into the circulatory system. Some OT- and AVP- producing neurons also project to other parts of the brain such as the hippocampus, amygdala, locus coeruleus, vagus nerve, and spinal cord (Buijs, 1978). Vasopressin is also expressed in the suprachiasmatic nucleus, the medial amygdala, and the bed nucleus of the stria terminalis (Sofroniew, 1983).

A single OT receptor has been identified. The OT receptor mediates the behavioral and biological actions of OT including uterine contraction during parturition and milk ejection during lactation (Kiss & Mikkelsen, 2005). Three AVP receptors have been isolated. The AVP V1a receptor mediates the effects of AVP on water reabsorption by the kidneys, vasoconstriction, and social behaviors (Lolait et al., 1995). The AVP V1b receptor stimulates ACTH secretion and is implicated in some of the behavioral effects of AVP (Caldwell, Lee, Macbeth, & Young, 2008). The AVP V2 receptor is only found in the periphery and is therefore unlikely to mediate the impact of AVP on social behavior, but has a role in the regulation of water retention and salt homeostasis via the kidneys.

Issues in Behavioral Endocrinology Research

Animal models provide the most compelling evidence for the involvement of OT and AVP in social behaviors. In behavioral endocrinology, establishment of causal inferences typically requires three lines of evidence. First, a hormonally-dependent behavior should be inhibited or reduced if its source or action is blocked. Second, restoration or artificial increase of the hormone should reinstate or enhance the target behavior. Third, there should be covariation between hormone concentration and the target behavior (Nelson, 2005). Collectively, these lines of evidence can provide support for the role of nanopeptides in social behaviors. Due to experimental and ethical constraints these kinds of evidence cannot always be collected in humans.

Animal studies inform us about the potential role of OT and AVP on social behaviors, but species differences in social behaviors, brain complexity, and receptors' localization prevents us from directly applying findings from the animal

literature to humans. With these caveats in mind, we first present animal studies that are suggestive of a link between OT and AVP and social behaviors and then describe human data that also support this association.

Animal Studies Examining Associations between OT, AVP, and Social Behaviors
Social Information Processing

Social information processing implicates OT and AVP. A standard paradigm to study social information processing in rodents is to measure the length of time spent investigating familiar and unfamiliar conspecifics. Time investigating familiar conspecifics usually decreases with repeated exposure to the same animal; therefore, the lack of reduction in time spent investigating familiar conspecifics is a proxy for deficits in social memory. Oxytocin knockout mice are unable to recognize familiar individuals despite repeated exposure (Choleris et al., 2003; Ferguson et al., 2000). This recognition deficit appears to be specific to social stimuli because these mice habituate to non-social cues and perform normally on spatial memory tasks (Choleris et al., 2003; Ferguson et al., 2000). Moreover, the deficits in social information processing can be restored with central injection of OT immediately prior to an initial encounter with a conspecifics (Ferguson, Aldag, Insel, & Young, 2001).

Vasopressin is also involved in social memory. Increased expression of AVP V1a receptors via viral vector transfer facilitates social recognition of familiar conspecifics (Landgraf et al., 2003). Conversely, central administration of AVP V1a receptor antagonist blocks social recognition in wild-type rats (Dantzer, 1987). Furthermore, AVP-deficient Brattleboro rats and AVP V1a and V1b receptor knockout mice exhibit deficits in social recognition (van Wimersma Greidanus, 1982;

Wersinger, Ginns, O'Carroll, Lolait, & Young, 2002) that can be restored by central AVP injection (Bielsky, Hu, Szegda, Westphal, & Young, 2004; Engelmann & Landgraf, 1994). These animal studies provide evidence of a role for OT and AVP in social memory.

Parental Care

Oxytocin and AVP influence the onset of parental care in mammals.

Nulliparous female rats usually avoid or attack pups, but start approaching them after parturition. Oxytocin has been implicated in the transition from avoidance of pups to maternal behavior such as nest building, licking and grooming, and crouching over pups. Intracerebral administration of OT induces maternal behavior in virgin female rats (Pedersen, Ascher, Monroe, & Prange, 1982). In contrast, central administration of OT receptor antagonist has been shown to delay or inhibit the onset of maternal behavior in female rats (Fahrbach, Morrell, & Pfaff, 1985). Furthermore, OT receptor density in the rat brain is positively correlated with time spent crouching over pups (Francis, Champagne, & Meaney, 2000; Olazabal & Young, 2006). These results suggest that OT is implicated in the initiation of maternal behavior in rats.

Oxytocin also appears to facilitate mother-infant bonding. In sheep, ewes establish a highly selective bond with her lamb quickly after parturition and subsequently reject any lamb that is not their own (Keverne, 1988). Increases in OT by intracerebral OT injections or vagino-cervical stimulation leads to the acceptance of unfamiliar lamb and induces maternal behaviors in virgin female ewes (Kendrick, Keverne, & Baldwin, 1987; Pedersen, 1997). Conversely, OT antagonist blocks the

formation of the mother-infant bond and inhibit maternal behavior in female sheep (Kendrick & Keverne, 1989), suggesting a role for OT in mother-infant bonding.

Vasopressin also has been implicated in parental behavior, especially paternal care. In prairie and meadow voles, central infusion of AVP increases paternal care, as evidenced by increased time licking, grooming, and crouching over pups and reductions in pup-directed aggression (Parker & Lee, 2001; Wang, Ferris, & De Vries, 1994). Conversely, AVP V1a receptor antagonist inhibits parental behavior in prairie vole (Wang et al., 1994). Similarly, Brattleboro rats, an AVP-deficient strain, show low levels of parental care in comparison to other rat strains (Wideman, 1990), providing evidence that AVP modulates parental behaviors.

Social Motivation

Affiliative behaviors are influenced by OT and AVP. In animal models, social motivation is assessed by measuring the amount of time spent in social contact. Chronic, central infusion of OT is associated with increased social contact time in adult prairie voles, rats, Mongolian gerbils, and squirrel monkeys (Razzoli, Cushing, Carter, & Valsecchi, 2003; Winslow & Insel, 1991; Witt & Insel, 1992). Furthermore, species differences in affiliative behaviors covary with cerebrospinal fluid (CSF) concentration of OT; highly-affiliative bonnet monkeys have higher CSF OT levels than the relatively asocial pigtail macaques (Rosenblum et al., 2002). Moreover, AVP also seems to modulate social motivation. Rats and prairie voles with viral vector-mediated over-expression of AVP V1a receptors spent more time in social contact than control animals who did not receive the viral vector manipulation (Pitkow et al.,

2001). These data suggest that OT and AVP influence the amount of social interaction in animals.

Social Bonding

Social bonding refers to the establishment of a long-term relationship between a male and a female. Social bond formation has been mainly studied with prairie voles, a monogamous rodent species that lives either in pairs or in family groups and engages in alloparental care (Getz & Carter, 1996). In this model, social bond formation is studied by measuring the amount of time spent with a partner in a three-chambered arena containing both the partner and a stranger (Williams, Catania, & Carter, 1992).

Prairie voles usually form a pair bond after mating, which is associated with releases of OT and AVP in several species (Carter, 1992; Carter, DeVries, & Getz, 1995). In prairie voles, intraventricular administration of OT induces partner preference formation, even in the absence of mating (Cho, DeVries, Williams, & Carter, 1999). Conversely, social preferences can be blocked by central injection of OT receptor antagonists (Cho et al., 1999; Williams, Insel, Harbaugh, & Carter, 1994). Chronic infusion and acute AVP injection also facilitate partner preference in prairie voles (Cho et al., 1999; Winslow, Hastings, Carter, Harbaugh, & Insel, 1993), while pair bonding formation is blocked by central injection of AVP V1a receptor antagonist (Cho et al., 1999; Winslow et al., 1993). This suggests that the establishment of long-term relationship between a male and a female is associated with OT and AVP in a monogamous rodent species.

Oxytocin Release in Response to Physical and Social Stimuli

Different types of social interaction elicit OT secretion. Lactation has been associated with increases in central and plasma OT in rats (Carter & Altemus, 1997a; Carter & Lightman, 1987; Heinrichs, Neumann, & Ehlert, 2002; Lightman & Young, 1989). Maternal licking and warm contact between pups and mother also enhance endogenous production of central OT (Holst, Uvnas-Moberg, & Petersson, 2002). Furthermore, rats stroked with a brush exhibit an increase in OT (Pedersen & Boccia, 2002; Stock & Uvnas-Moberg, 1988). Even mere social interaction with conspecifics of the opposite sex can elicit endogenous secretion of OT in virgin male rat (Hillegaart, Alster, Uvnas-Moberg, & Ahlenius, 1997). This indicates that social interaction and non-noxious physical stimuli can trigger the release of OT in rats.

Early Relationships Quality

The quality of early interpersonal relationships may have a long-term impact on OT and AVP systems. In cross-fostering studies in which pups from low-licking mothers are transferred to a high-licking mother and vice-versa, pups assigned to a high-licking mother have increased OT and AVP receptor binding compared to pups assigned to a low-licking mother, regardless of the licking behavior of the biological mother (Francis, Young, Meaney, & Insel, 2002). In primates, nursery-reared monkeys have lower CSF OT levels and have more disturbed and asocial behavior such as avoidance of gaze and physical contacts, stereotypic and self-directed behaviors, and attachment to inanimate objects, compared to mother-reared monkeys (Winslow, 2005). Moreover, nursery-reared monkeys do not display attenuated cortisol reactivity when exposed to a stressor with a social companion, while mother-

reared monkeys benefited from the presence of conspecifics when exposed to the same stressor (Winslow, Noble, Lyons, Sterk, & Insel, 2003). These studies suggest that early relationships influence OT and AVP activity, and social behaviors.

Regulation of the Stress Response

Oxytocin and AVP are part of a system that restores homeostasis following stress, as they are both secreted in response to stress and then exert inhibitory actions on stress responses. Forced swim test and exposition to an elevated maze induce central release of OT and AVP (Wotjak et al., 1998). Furthermore, male rats exhibit an increase in central, but not plasma, OT after a social defeat (Ebner, Wotjak, Landgraf, & Engelmann, 2000). Similarly, social isolation stress induces increases in basal, plasma OT levels in females and increases in OT secretion in response to stress for both males and females prairie voles (Grippe et al., 2007). This indicates that both social and non-social stressors trigger OT and AVP secretion.

Release of OT and AVP also has an inhibitory effect on stress responses, at least as measured by the release of glucocorticoids. Intracerebral administration of OT dampened the HPA axis and autonomic responses to stress (Neumann, 2002). Furthermore, central OT and AVP injection reduce anxiety as evidenced by increased exploration of novel environment in rats (Dharmadhikari, Lee, Roberts, & Carter, 1997; McCarthy, McDonald, Brooks, & Goldman, 1996). In contrast, rats who received OT receptor antagonist exhibit increased ACTH response to immobilization and elevated maze stressors, providing evidence for the regulatory role of OT in the stress response (Neumann, Kromer, Toschi, & Ebner, 2000).

The OT release elicited by social interaction and physical contacts seems to attenuate stress reactivity. Lactation in rodents increases OT, which decreases basal levels of ACTH and cortisol (Carter & Altemus, 1997b). Furthermore, hamsters heal an experimental wound faster when they are exposed to stress with familiar conspecifics than when they are housed alone. However, paired-housed hamsters who received an OT antagonist do not heal faster than individually-housed animals, suggesting that the nanopeptide mediate the positive health impact associated with social relationships (Detillion, Craft, Glasper, Prendergast, & DeVries, 2004).

Summary of Animal Studies

Animal studies using experimental designs provide strong evidence for a role of OT and AVP in social information processing, parental care, social motivation, and social bonding. Non-noxious physical contacts, social interactions, and stress can trigger the release of OT and AVP. Furthermore, early relationships appear to have a long-term impact on the activity of these nanopeptides. However, due to species differences in social behaviors, brain complexity, and receptors distribution it is unclear which of these findings are applicable to humans.

Human Literature Linking OT, AVP, and Social Behaviors

Three major paradigms have been used to study the influence of these nanopeptides on social behaviors in humans. The first paradigm consists of an experimental manipulation of brain levels of OT or AVP mainly via intranasal infusion of a synthetic OT or AVP compound. Intranasal administration of AVP leads to elevations in CSF AVP levels within 10 minutes. This elevation persists for about

80 minutes, suggesting that it might affect brain functions mediating social behaviors (Born et al., 2002). The second research paradigm aims at eliciting endogenous secretion of OT and AVP via social interaction, physical contacts, or exposition to stressors. The third paradigm consists of the observation of covariations between plasma levels of OT, AVP, and social behaviors.

Experimental Manipulation of CSF OT and AVP levels

Human social information processing seems to be modulated by OT and AVP. Intranasal OT administration leads to improved performance on a face recognition test 30 minutes and 24 hours after stimuli presentation, compared to the placebo injection (Guastella, Carson, Dadds, Mitchell, & Cox, 2008; Savaskan, Ehrhardt, Schulz, Walter, & Schachinger, 2008). Furthermore, participants are better able to label the emotion expressed by a person via a picture of his/her eyes when they receive OT than when they are administered a placebo injection, suggesting an enhanced ability to decipher nonverbal social cues (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007).

Manipulation of AVP CSF levels influences perception of friendliness and facial expression in response to human face stimuli. For men, intranasal AVP administration decreases perception of friendliness in response to neutral facial expression, while for women the same manipulation increases perception of friendliness to neutral and happy faces. Similarly, among men intranasal AVP levels increases activation of the corrugator supercilii, a facial muscle associated with agonistic facial motor pattern, while it stimulates the zygomaticus, a facial muscle involved in smiling in women (Thompson, Gupta, Miller, Mills, & Orr, 2004;

Thompson, George, Walton, Orr, & Benson, 2006). This suggests that the effects of AVP administration display a sexually dimorphic pattern in response to human face stimuli, with men showing more agonistic-like response, while women exhibit more an affiliative-like response.

Intranasal OT administration facilitates approach and prosocial behaviors in experimental economics tasks. In these tasks, a first participant is asked to give a certain amount of money to a second participant. The second participant can either accept the money, leading to the transfer of the previously stated amount of money, or reject the offer, leading to loss of the money for both participants. Intranasal administration of OT leads to a 21% increase in money transfer from participant 1 to participant 2, a finding that the authors presume indicates greater generosity associated with the OT treatment (Zak, Stanton, & Ahmadi, 2007). In another version of the game, participant 1 is asked to give a certain amount of money to participant 2. The amount is tripled following the transfer and participant 2 can return all, some, or none of the money to participant 1. In this task, the amount transferred by participant 1 entails potentially greater possibility of loss, but also larger potential for cooperation gains. Intranasal OT treatment is associated with increased amount of money transfer from participant 1 to participant 2 (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005). In controls, the amount of money transferred by participant 1 covaries with plasma OT levels (Zak, Kurzban, & Matzner, 2005). The increase in interpersonal trust induced by OT administration persists even when the participant is informed that participant 2 is not likely to give some money back (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008).

Pharmacological increases in OT also enhance the stress buffering effect of social support. Participants exposed to a laboratory stressor, the Trier Social Stress Test, who were both accompanied by their best friend and received intranasal administration of OT had lower increases in cortisol and anxiety, compared to individuals who either were supported by their best friend, or received the OT treatment, or were alone and received a placebo injection (Heinrichs, Baumgartner, Kirschbaum, & Ehlers, 2003). Furthermore, women who exhibit increases in plasma OT levels in response to lactation or while holding their baby had an attenuated response to a laboratory stressor, compared to women who display no increase in OT during these two tasks (Light et al., 2000). Moreover, women who had caesarean sections had fewer OT pulses and were less likely to describe themselves as having a calm personality and high levels of sociability, compared to women who vaginally delivered (Nissen et al., 1996). Collectively, these results suggest that elevations in OT attenuate stress responses in humans.

In sum, in accord with animal studies, pharmacological increases in OT in humans improve memory for social stimuli, increase trust and prosocial behavior, and enhance the stress buffering effect of social support. Administration of AVP increases perception of friendliness and affiliative non-verbal facial expression in women, while it decreases perception of friendliness and increased agonistic non-verbal facial expression in men. These experimental studies provide the strongest evidence implicating OT and AVP in social processes in humans.

Experimental Elicitation of Endogenous Expression of OT and AVP

Oxytocin appears to be released in response to non-noxious physical contacts in humans. Lactation increases plasma levels of OT (Carter & Altemus, 1997b). Furthermore, mother-infant physical contacts stimulate the release of plasma OT, but not AVP, in both the mother and the child (Fries, Ziegler, Kurian, Jacoris, & Pollak, 2005; Matthiesen, Ransjo-Arvidson, Nissen, & Uvnas-Moberg, 2001). In adults, massage has been associated with increase in plasma OT levels (Wikstrom, Gunnarsson, & Nordin, 2003). Moreover, sexual intercourse and orgasm have also been associated with secretion of plasma OT (Carmichael et al., 1987; Murphy, Seckl, Burton, Checkley, & Lightman, 1987).

Social interactions in laboratory do not appear to elicit secretion of plasma OT. Cohabiting couples who undergo a 10-minute warm contact intervention in which they were instructed to sit close to each other, talk about their relationship, watch a romantic clip, and then hug each other do not exhibit an increase in plasma levels of OT after the interaction (Grewen, Girdler, Amico, & Light, 2005; Light, Grewen, & Amico, 2005). Furthermore, neither verbal social support, a 10-minute massage, or no support from their partner elicited increases in plasma OT among women waiting to perform a psychological stress task. However, women who received a massage from their partner had an attenuated cortisol response to stress, compared to women randomized to the two other conditions (Ditzen et al., 2007). In an intervention study, neither the couples randomized to give massages to their partner 3 times per week for 4 weeks, nor the “no intervention” control couples exhibit a significant change in plasma OT (Holt-Lunstad, Birmingham, & Light, 2008). In another study, women who received a 10-minute massage and were asked to re-experience a positive and a

negative emotion associated with, respectively, love and loss in social relationships do not display changes in plasma OT levels (Turner, Altemus, Enos, Cooper, & McGuinness, 1999).

Acute stress does not seem to reliably increase plasma OT levels in humans. Lactating and non-lactating women who perform a speech and mental arithmetic task do not exhibit increases in plasma OT (Altemus et al., 2001). Similarly, older women who perform the Trier Social Stress Task do not display a change in plasma OT even 60 minutes after the stressor (Taylor et al., 2006). Moreover, young adult women who complete a speech task combined with a Stroop task do not have elevation in OT after the stressor (Light, Grewen et al., 2005). Among women exposed to an uncontrollable auditory stressor, only those with high levels of neuroticism exhibit an increase in plasma OT (Sanders, Freilicher, & Lightman, 1990). However, this result is not always replicated (Ueda, Yokoyama, Irahara, & Aono, 1994). Therefore, OT does not appear to reliably increase following exposure to an acute psychological stressor in humans.

In sum, non-noxious physical contacts are associated with increases in OT, while neither single episode of social interaction, nor acute stress in laboratory appear to reliably elicit release of OT in plasma. This difference may be a true species difference. Alternatively, the level of an acute stressor necessary to elicit OT release into plasma in humans may be higher than in the animal models. In addition, the apparent discrepancy with the animal literature might be explained by the fact that central OT levels are studied in animal studies, while the human work examines peripheral levels of the peptide.

There are controversies regarding the association between central and peripheral levels of OT and AVP. Some studies have found concordance between central and peripheral release of OT (Moos & Richard, 1989), while other studies have observed small, non-significant associations between central and peripheral OT and AVP in response to certain stimuli (Landgraf & Neumann, 2004). Overall, basal plasma OT and AVP levels appear to reflect, to a certain extent, central levels of these peptides. However, central OT and AVP secretion triggered by external stimuli may not immediately correspond to peripheral levels of the same peptide.

Another possibility is that the intensity or the duration of the stimuli used in human studies are not of a great enough magnitude to elicit endogenous release of OT. In rats, a single dose of OT or a single episode of stroking with a brush increased cortisol and blood pressure in rats, while chronic stroking or OT administration lead to long-term reduction in cortisol, blood pressure, and anxiety that persisted even after the OT or stroking manipulation had ended (Holst et al., 2002; Petersson, Alster, Lundeberg, & Uvnas-Moberg, 1996). Although OT is not directly measured in these studies, this shows that the biological actions of OT differ following acute and chronic secretion of the hormone. In a similar vein, a couple intervention including a hug between partner did not elicit increases in OT, but frequency of hugs in the past months was positively associated with circulating levels of OT (Light, Grewen, & Amico, 2005). This raises the possibility that plasma OT levels could reflect recent history of social contact or chronic differences in the social environment (Taylor, et al., 2006) rather than the impact of a single episode of interaction. Similarly, chronic rather than acute stress might be necessary to elicit plasma increases in OT or AVP.

Covariations Between OT, AVP and Social Behaviors

Parental care appears to covary with OT. Plasma OT levels during the first and third trimester as well as one month postpartum positively correlated with mothers' maternal behavior one month postpartum and feelings of attachment toward the infant throughout the pregnancy and at one month postpartum (Feldman, Weller, Zagoory-Sharon, & Levine, 2007; Levine, Zagoory-Sharon, Feldman, & Weller, 2007). Furthermore, plasma OT levels during breast-feeding is positively related to parental behavior (Uvnas-Moberg, 1990). This suggests that OT is also associated with parental care and mother-infant bonding in humans.

The quality of early relationships may impact OT and AVP levels in humans. Children that were reared in an orphanage for their first year of life had lower basal levels of urinary AVP and exhibited an impaired increase in OT elicited by mother-infant interaction, compared to children reared by their biological parents (Fries et al., 2005). Moreover, in healthy young adults, basal, plasma OT level correlates positively with self-reported quality of parental care during their childhood (Gordon et al., 2008). Furthermore, adult males who had experienced early parental separation exhibit an increase in cortisol associated with intranasal OT administration, while participants without such history have a decrease in cortisol associated with the pharmacological injection of OT (Meinlschmidt & Heim, 2007). Taken together these results suggest that the quality of early relationships may alter the efficacy of the OT and AVP systems.

Vasopressin appears to be related to marital status and marital quality in adults. Among men involved in a romantic relationship for at least 5 years, a polymorphism of the AVP V1a receptor gene is associated with lower self-reported

partner bonding, more frequent marital crises in the past year, and an increased likelihood of cohabiting rather than being married (Walum et al., 2008). These results, although not observed in women, imply that the efficacy of the vasopressin system influences pair bonding in humans.

Plasma OT levels appear to reflect the quality of current interpersonal relationships. Among individuals undergoing a warm touch intervention with their partner, greater perceived support from their spouse and a higher frequency of hugs and massage with their partner in the past month are associated with higher basal, plasma levels of OT (Light, Grewen, & Amico, 2005). Similarly, among women who are asked to hold their baby before a speech task, higher levels of perceived social support is associated with higher levels of OT (Light et al., 2004). Moreover, women who report sharing their emotions and feelings with their friends more frequently have higher plasma levels of OT (Tops, van Peer, Korf, Wijers, & Tucker, 2007). These studies do not speak to the causal role or the direction of the relationship between OT and social behavior, however they are suggestive of an association between circulating levels of the peptide and relationship quality.

Although most studies report a positive association between greater relationship quality and circulating levels of OT, some studies have reported positive association with relationship stress and plasma OT levels. In young adult women, baseline level of OT was positively associated with greater intrusiveness in social relationships (Turner, Altemus, Enos, Cooper, & McGuinness, 1999). However, these results were not replicated in a subsequent study (Turner et al., 2002). Among older women exposed to a psychological stressor, higher plasma OT level was associated with fewer contacts with their mother and their main social group, and more frequent

reports that their husband was less likely to understand their feelings, to appreciate them, and that they felt that they could not talk to him about their problems (Taylor et al., 2006).

To explain these results, Taylor (2006) proposed the tend and befriend theory stipulating that humans, especially women, tend to seek social support in response to stress as opposed to always exhibiting a fight or flight response. In this context, OT is part of biological system that regulates social contact in times of stress. When an individual is socially isolated, experiences social conflict, or reports low relationship quality, enhanced OT production may provide an impetus to seek relationships to cope with stressful events (Taylor, 2006). Therefore, higher plasma OT in times of stress may be indicative of relationship stress.

Measurement issues might also explain these discrepant findings. The sensitivity of the OT assays is problematic in humans. Reported values are often close to the detection values of the assay, suggesting the possibility of large experimental error (Carter et al., 2007). Potentially, this can be even more important among older adults who produced less OT than younger adults. Furthermore, psychometrically this literature is plagued with a lack of clear conceptualization of the social variables being measured, the use of non-validated instruments and frequent single item analyses. These factors may contribute to the non-replication of results across studies. To remedy this gap in the literature, we examine the association between indicators of marital quality and plasma levels of OT and AVP.

Measurement of Marital Quality

Marital relationships are often designated as the individual's main source of social support (Burman & Margolin, 1992). The importance of these relationships is also demonstrated by the fact that married individuals have less morbidity and mortality than single individuals and that distressed marriages are associated with poorer health outcomes (Kiecolt-Glaser & Newton, 2001). Given the central role of close partnership in the lives of humans, it is not surprising that marital quality is associated with peptides of a biological system that is implicated in the regulation of social attachment (Grewen et al., 2005).

Marital quality has been defined as the subjective evaluation of the relationship (Bradbury & Fincham, 1987). Although, it is often assessed through self-report questionnaires, the social learning model suggests that marital quality is determined by marital interaction patterns (Jacobson, 1979). In fact, marital interaction in laboratory reflects subjective evaluation of marital quality (Pasch & Bradbury, 1998). Specifically, couples that display a higher rate of negative interactions report lower marital quality (Bradbury & Karney, 2004). Positive behaviors such as providing support are also related to global assessment of the quality of the relationship (Pasch & Bradbury, 1998). Marital interaction tasks in laboratory clearly increase predictive power over self-reported questionnaires because it allows objective observation of interaction patterns of which the participants may not be consciously aware (Bradbury & Karney, 2004). Therefore, studies including both objective data on positive and negative behaviors during a marital interaction task as well as self-report marital quality assessments may provide the most comprehensive assessment of marital quality.

The Present Study

Experimental studies provide strong evidence of a role for OT and AVP in the establishment of partner preference and pair bonding in animals. In humans, several studies have reported positive correlations between indicators of marital quality and plasma OT. However, these studies have used non-standardized measures of marital quality and various OT assays. Moreover, although animal studies and some human studies clearly suggest a role for AVP in pair bonding, no study to date have examined association between indicators of marital quality and plasma levels of AVP in humans.

The goal of the present study is to investigate the relationship between different indicators of marital quality and circulating plasma levels of OT and AVP. Married couples were invited for a 24-hour admission at the OSU Clinical Research Center (CRC). During the visit, each couple participated in a structured social support interaction task to assess positive and negative behaviors during marital interaction. Each partner also completed self-report measures of marital quality and negative marital interactions. Participants provided two blood samples during the visit for OT and AVP analyses.

Given that couples were invited to participate in a non-threatening, socially supportive discussion, the hypotheses of this study were:

- 1) Higher plasma OT levels will be associated with fewer negative and more positive behaviors during a marital interaction task, fewer self-reported negative marital interactions in the past month, and greater marital satisfaction;

- 2) Higher plasma AVP levels will be associated with fewer negative and more positive behaviors during a marital interaction task, fewer self-reported negative marital interactions in the past month, and greater marital satisfaction;
- 3) Given that some studies have found that men and women respond differently to intranasal AVP and that an association between AVP V1a receptor polymorphism and marital distress was only found in men (Thompson et al., 2006; Walum et al., 2008), we hypothesized that women will have a stronger association between marital quality and plasma AVP, compared to men .
- 4) Indicators of marital quality will be associated with plasma OT and AVP levels, even after controlling for differences in health behaviors (Kiecolt-Glaser & Glaser, 1988b).

CHAPTER 2

METHOD

Participants

Thirty-seven heterosexual, married couples were recruited as part of a larger study on marital stress and wound healing through newspaper and radio ads, notices posted on campus and in the community, and referrals from other participants. Exclusion criteria included 1) health problems or related medications that had an obvious immunological or endocrinological component or consequences for wound healing (e.g., cancer, recent surgeries, strokes, diabetes mellitus, peripheral vascular disease, conditions such as asthma or arthritis that required regular use of antiinflammatories), 2) blood pressure medication, smoking, or using excessive alcohol or caffeine, and 3) pregnancy or anti-diuretic medication use. Each spouse was paid \$500 for participation in the research project. The Ohio State University Biomedical Research Review Committee approved the project; all subjects gave written informed consent prior to participation.

Protocol

Thirty-seven couples (74 individuals) participated in a 24-hour visit at the CRC, a hospital-based research unit. At 7 AM, couples were admitted to the GCRC, fed a standard breakfast (after fasting since midnight before admission), and given

questionnaires to complete. A heparin well was inserted in each subjects' arms to facilitate blood draws throughout the day. The first blood sample for OT and AVP analyses was taken at 7:45 AM. At 9:15 AM, nurses performed the experimental blistering procedure for the wound healing study (Kiecolt-Glaser et al., 2005). At roughly 10:45 AM, couples were positioned in chairs facing each other in front of a curtain, completed several questionnaires, and sat quietly for 10 minutes before starting the marital interaction task. The marital interaction tasks were videotaped and the research team remained out of sight during all discussions. At 11:30 AM couples started a second interaction task during which they were asked to discuss the history of their relationship for 30 minutes (Veroff, Sutherland, Chadiha, & Ortega, 1993). A second blood sample was drawn at 12:00 after that task for OT and AVP assays. To ensure consistent physical activity across dyads and admissions, couples remained together in the same room for the remainder of the day. Throughout the admission, couples were encouraged to regularly drink water to facilitate blood draws and prevent AVP fluctuations due to changes in plasma osmolality.

The first interaction task was designed to assess partners' behaviors when soliciting and offering social support. A social support task was chosen because negative behaviors are observed consistently across social support and conflict discussion tasks, while positive behavior are more likely to be elicited by a social support discussion (Pasch & Bradbury, 1998). In the structured social support task, each spouse identified an important personal characteristic, problem, or issue that he or she wished to change, but were explicitly instructed to avoid discussing issues that might lead to marital dissension. Each spouse was then asked to talk about what they would like to change about themselves, while the partner was instructed to be

involved in the discussion in whatever way he or she wished. Roles were reversed after 10 minutes of discussion (Pasch & Bradbury, 1998). Marital behaviors during the structured social support interaction were analysed using the Rapid Marital Interaction Coding System (Heyman, 2004).

Behavioral Observational Coding System

The Rapid Marital Interaction Coding System (Heyman, 2004) was used to quantify marital interaction data during the social support task. Negative behaviors are computed by summing five RMICS codes: psychological abuse, distress-maintaining attributions, hostility, dysphoric affect, and withdrawal (Crowell et al., 2002; Kiecolt-Glaser et al., 2005). A positive behavior index was created by aggregating the acceptance, relationship-enhancing attribution, self-disclosure, and humour codes (Crowell et al., 2002). The RMICS has high reliabilities both for the overall system as well as for individual codes, and it discriminates distressed from non-distressed couples (Heyman, 2004).

Self-Report Questionnaires

The Marital Adjustment Test (Locke & Wallace, 1959) assessed marital adjustment and satisfaction. Participants were asked to rate their current level of happiness in their marriage, the degree agreement with their spouse on several topics such as finance, in-laws, or sex relations, and the quality of different types of marital interaction. Possible score range from 2 to 158 with higher score indicates higher relationship satisfaction. A cut-off score of 100 distinguishes between distressed and

non-distressed couples (Crane, Allgood, Larson, & Griffin, 1990; Freeston & Plechaty, 1997). The scale had a Cronbach's α of .86.

The Test of Negative Social Exchange (Ruehlman & Karoly, 1991) assessed negative social interactions. This questionnaire included 18 items assessing the frequency of occurrence of negative social exchanges in the past month. Participants completed a version of the questionnaire referring to their interaction with their spouse. This questionnaire included four factor-analytically derived subscales. The Hostility subscale assessed interpersonal conflict. The Interference subscale evaluated social hindrance. The Insensitivity subscale measured communicative disengagement, and the Ridicule subscale assessed social teasing. The TENSE has good discriminant validity as it correlated only from .03 to .16 with the Inventory of Socially Supportive Behavior. In terms of convergent validity, the TENSE correlates .28-.30 with the Social Hindrance subscale of the Social Support and Social Hindrance Inventory. Cronbach's α for the scale was .96. The total score was computed by summing the average of each subscale.

Health behaviors such as alcohol, caffeine, or medication use in the past week were evaluated (Kiecolt-Glaser & Glaser, 1988b). A question from Baecke et al. (1982) was used to quantify recent physical activity. Height and weight measurements were taken to calculate participant's body mass index (BMI). The Pittsburg Sleep Quality Index assessed sleep quality and sleep disturbances in the past month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). This self-reported questionnaire comprised seven subscales evaluating subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. A higher score indicated greater sleep disturbances. Using a

clinical cut-off of 6, the scale shows a sensitivity of 89.6% and a specificity of 86.5% in distinguishing between good and poor sleepers. The scale has a good internal consistency (Cronbach's α of 0.85) and a high test-retest reliability ($r = .86$) at 45 days (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002).

After the structured social support task, participants were asked to rate on a 9-point likert scale (from 1- totally disagree to 9- totally agree) to what extent they endorse the following statements regarding their discussion: "I felt that my partner understood me; I felt that my partner supported me; I was able to work productively; I'm satisfied with the outcome of the discussion." Using a liberal cut-off, we considered that participants rating less than 5 (the middle point) on either of the first two statements were considered as not perceiving their marital interaction as socially supportive.

Plasma Oxytocin and Vasopressin Levels

Plasma OT and AVP were assayed by enzyme immunoassay (Assay Designs, Ann Arbor, MI), per kit instructions. The assays were highly sensitive with minimum detection rate of 4.68 pg/ml for OT and 3.39 pg/ml for AVP. The intra and inter-assay variation coefficient were 2.68% and 14.45% for OT and 5.7% and 2.5% for AVP. The cross-reactivity between the OT and AVP assays was less than 0.04% (Carter et al., 2007). Samples were run undiluted in duplicate, and all samples for a couple were run at the same time. Assays were performed at the laboratory of Sue Carter, PhD.

Statistical analyses

Data about marital quality obtained from two individuals in a romantic relationship are not independent. This lack of independence between the husband and the wife data violates an assumption implied in the use of linear regression models. Several approaches have been proposed in the literature to deal with dyadic data. The first is to ignore the independence and treat them as independent data. This approach is problematic because it leads to inflation or deflation of the Type I error, rendering the p -values inaccurate (Kenny, 1995). The second approach consists of averaging the data of the two members of the dyad and using the dyad as the unit of analysis. This analytic strategy clearly results in a loss of information and is not readily applicable with physiological data because important metabolic differences between individuals render the use of an average variable not meaningful. A third approach involved conducting separate analyses for husbands and wives. This approach leads to a loss of power because the sample size is reduced in half in each analysis and prevents us from performing direct comparison between husbands and wives. A fourth approach uses hierarchical linear modeling and treats each individual as nested within a couple to control for the interdependence between the husband and wife data. This approach appears the most appropriate for our data. We also considered using the Actor-Partner Interdependence Model to estimate the effects of both partner independent variables on each partner dependent variables (Campbell & Kashy, 2002). However, our relatively small sample size would not allow us to reliably estimate all the actor and partner main effects as well as their interactions with gender. Similarly, structural equation modeling was not viable option because of our sample size.

Hierarchical linear models (HLM) were used to assess linear relationships between plasma OT and AVP and indicators of marital quality. All the slopes of the level-1 predictors were constrained to be equal because estimating a random effect for these variables may lead to non-convergence problems with dyadic data (Newsom, 2002). Intercepts, however, were estimated as random effects. Given the study's sample size, restricted maximum likelihood was used as the estimation method. A grand mean centering of the independent variables was performed to facilitate the interpretation of the dyadic data.

Hierarchical linear models were fitted with OT and AVP as dependent variables, the MAT and the TENSE as individual-level predictors, and the positive behaviors and negative behaviors as couple-level predictors. Couple-predictors were used because husband and wife data tend to be highly correlated and because of our interest of marital behaviors as a proxy for marital functioning (Ewart, Taylor, Kraemer, & Agras, 1991; Lindahl, Clements, & Markman, 1997). Couple-level variables were created by summing the husbands and wives' positive and negative behaviors following convention in the marital literature (Ewart et al., 1991; Lindahl et al., 1997). Because age and gender have been found to influence basal OT levels (Holt-Lunstad et al., 2008; Turner et al., 1999) they were included in the OT model. In contrast, only gender was included in the AVP models because there is no significant change in plasma AVP with aging (Duggan, Kilfeather, Lightman, & O'Malley, 1993). Gender was effect coded (-1 and 1) to facilitate interpretation. Estrogen medication use was also included in the OT as it has been shown to enhance the biological activity of the hormone (McCarthy, 1995). Equations for each model are found below.

Hypothesis 1:

$$\text{Level 1: } Y_{ij}(OT) = \beta_{0j} + \beta_{1j}(\text{age}) + \beta_{2j}(\text{gender}) + \beta_{3j}(\text{estrogen}) + \beta_{4j}(\text{MAT}) + \beta_{5j}(\text{TENSE}) +$$

$$r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Positive Behaviors}) + \gamma_{02}(\text{Negative Behaviors}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

Hypothesis 2:

$$\text{Level 1: } Y_{ij}(AVP) = \beta_{0j} + \beta_{1j}(\text{gender}) + \beta_{2j}(\text{MAT}) + \beta_{3j}(\text{TENSE}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Positive Behaviors}) + \gamma_{02}(\text{Negative Behaviors}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

Hypothesis 3:

$$\text{Level 1: } Y_{ij}(AVP) = \beta_{0j} + \beta_{1j}(\text{gender}) + \beta_{2j}(\text{MAT}) + \beta_{3j}(\text{TENSE}) + \beta_{4j}(\text{MAT X Gender})$$

$$+ \beta_{5j}(\text{TENSE X Gender}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Positive Behaviors}) + \gamma_{02}(\text{Negative Behaviors}) + \gamma_{03}(\text{Positive Behaviors X gender}) + \gamma_{04}(\text{Negative Behaviors X Gender}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

Hypothesis 4:

$$\text{Level 1: } Y_{ij}(OT) = \beta_{0j} + \beta_{1j}(\text{age}) + \beta_{2j}(\text{gender}) + \beta_{3j}(\text{estrogen}) + \beta_{4j}(\text{MAT}) + \\ \beta_{5j}(\text{TENSE}) + \beta_{6j}(\text{alcohol}) + \beta_{7j}(\text{caffeine}) + \beta_{8j}(\text{exercise}) + \beta_{9j}(\text{BMI}) + \\ \beta_{10j}(\text{sleep}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Positive Behaviors}) + \gamma_{02}(\text{Negative Behaviors}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

$$\beta_{7j} = \gamma_{70}$$

$$\beta_{8j} = \gamma_{80}$$

$$\beta_{9j} = \gamma_{90}$$

$$\beta_{10j} = \gamma_{10}$$

$$\text{Level 1: } Y_{ij}(AVP) = \beta_{0j} + \beta_{1j}(\text{gender}) + \beta_{2j}(\text{MAT}) + \beta_{3j}(\text{TENSE}) + \beta_{4j}(\text{alcohol}) + \\ \beta_{5j}(\text{caffeine}) + \beta_{6j}(\text{exercise}) + \beta_{7j}(\text{sleep}) + \beta_{8j}(\text{BMI}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Positive Behaviors}) + \gamma_{02}(\text{Negative Behaviors}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

$$\beta_{7j} = \gamma_{70}$$

$$\beta_{8j} = \gamma_{80}$$

Previous human studies have failed to find a relationship between social interaction or psychological stressors in laboratory and changes in OT (Altemus et al., 2001; Grewen et al., 2005; Taylor et al., 2006). In addition, circadian fluctuations in OT and AVP are minimal in the morning (Forsling, Montgomery, Halpin, Windle, & Treacher, 1998). A repeated measure analysis of variance was performed to assess changes in OT and AVP during the visit. Because there was no significant change in neuropeptides over time, OT and AVP measurements were averaged to obtain a better estimate of their basal levels.

The distributions of the OT and AVP were positively skewed. A base 10 logarithmic transformation was used to normalize their distribution. The TENSE and the negative behaviors variables had an L-shaped distribution with more than 20% of the sample having no negative marital interactions. Given our inability to normalize their distribution with data transformations, dichotomous variables were created using a median split of the TENSE, negative behaviors, and alcohol use data. The three variables were effect coded to facilitate interpretation. Spearman's rho and zero-order correlations were used to assess inter-relationships between the study's variables. The α significance level was set at .05. Statistical analyses were performed using SPSS version 17.0 and SAS version 9.1.

CHAPTER 3

RESULTS

Thirty-seven couples provided blood samples for OT and AVP analyses. Due to technical difficulties, the blood sample of one participant was not assayed. Furthermore, one couple did not complete the TENSE and two participants did not answer all the questions of the MAT. Participants' sociodemographic characteristics are presented in Table 1. Participants' ages ranged from 22 to 73 with a mean of 38.47 ($SD = 11.99$). Couples had been married from 2 to 39 years, with a mean of 11 years ($SD = 9.63$). Most participants (78%) had only been married once. Couples had two children on average ($SD=1.63$).

Participants' health behaviors are presented in Table 2. The most common medications taken by the participants were estrogen/progesterone supplements (10), antidepressants (6), steroid nasal sprays (5), non-steroidal anti-inflammatory drugs (3), antacids (3), and antihistamines (3). The low frequency of medication use in our sample reflects the stringent health exclusion criteria.

Manipulation Check

Most participants felt understood (mean = 7.37; $SD = 1.55$) and supported (mean = 7.54; $SD = 1.45$) by their partner during the discussion. Overall, participants

reported that they were able to work productively during the discussion, (mean = 6.53; SD = 1.44) and were moderately satisfied with the outcome of the discussion (mean = 6.45; SD = 1.66). Based on our cut-off criteria, 4 participants did not report that their partner understood and supported them during the discussion.

Changes in OT and AVP over time

Controlling for participants' age and gender, OT plasma levels did not significantly change from baseline to the end of the discussion, $F(1, 63) = 0.02, p = .90$. This lack of change over time was observed for both men and women, $F(2, 62) = 0.03, p = .86$. Similarly, controlling for participants' gender, AVP plasma levels did not significantly change during the CRC visit, $F(1, 63) = 0.01, p = .93$, with no difference between husbands and wives, $F(2, 62) = 1.5, p = .23$. Given the lack of change in plasma OT and AVP over time, the two OT and AVP measurements were averaged to obtain a better estimate of the basal levels of these peptides.

Descriptive Statistics and Inter-correlations Between Marital Quality and Nanopeptides Variables

Descriptive statistics of the study variables are presented in Table 2. Spearman's rho correlations between behavioral and self-reported indicators of marital quality and OT and AVP plasma levels are included in Table 3. Spearman's rho correlations were used to assess relationships between the raw, non-transformed data because they did not require any assumptions about the distribution of the study variables. Zero-order correlations were also performed because they better reflected

the analyses conducted in the hierarchical linear models. Zero-order correlations using the log-transformed and dichotomous variables are presented in Table 4.

Marital Quality and OT Plasma Levels

The first model tested whether the individual-level predictors MAT and TENSE and the couple-level predictors positive and negative behaviors were associated with basal OT plasma levels. Table 5 shows the results of the model for the prediction of the log-transformed OT data. Positive behaviors during the marital interaction task were positively associated with OT plasma levels. Figure 1 illustrates the relationship between couples' positive behaviors and OT plasma levels. Furthermore, gender was a significant predictor of plasma OT levels. Men ($M = 2.34$, $SEM = .05$) had significant lower OT plasma levels, compared to women ($M = 2.55$, $SEM = .07$). Moreover, a marginally significant, negative association between age and OT plasma levels was observed. Self-reported marital satisfaction, negative behaviors, and self-reported negative marital interactions were not significantly related to OT.

Marital Quality and AVP Plasma Levels

The second model evaluated whether individual-level predictors MAT and TENSE and the couple-level predictors positive and negative behaviors predicted basal levels of AVP. Table 6 contains the estimates of the model predicting basal levels of the log-transformed AVP data. The frequency of negative behaviors during the marital interaction task was negatively associated with AVP. Participants who displayed a low frequency of negative behaviors during the marital interaction task ($M = 1.85$, $SEM = .05$) had higher levels of AVP than individuals who exhibited a

high frequency of negative behaviors ($M = 1.70$, $SEM = .05$). Similarly, the frequency of self-reported negative marital interactions in the past month was significantly, negatively related to AVP plasma levels. Participants who reported low levels of negative marital interactions ($M = 1.85$, $SEM = .05$) had higher AVP levels than participants with high levels of negative marital interactions in the past month ($M = 1.68$, $SEM = .05$). Figures 2 and 3 illustrate the relationship between observed and self-reported negative behaviors and AVP plasma levels. Self-reported marital satisfaction and positive behaviors during the marital interaction task were not significantly related to AVP. Also, there was no gender difference in AVP levels.

Gender, Marital Quality and AVP

We also hypothesized that gender would moderate the relationship between marital quality and AVP plasma levels. This moderation effect was tested by including gender by marital quality interaction terms in the AVP model. Table 7 contains the estimates of the model testing for the gender moderation effect. None of the gender by marital quality interaction terms were significant predictors of AVP plasma levels.

Marital Quality, Health Behaviors, OT, and AVP

In psychoneuroendocrinology research, health behaviors are obvious confounding variables when evaluating the relationships between psychological characteristics and hormone production. In order to evaluate whether marital quality influenced OT and AVP plasma levels over and above differences in health behaviors, alcohol and caffeine use, exercise, body mass index, and sleep variables were included in the model. Tables 8 and 9 contain the estimates of the models including health

behaviors variables. In the OT model, average weekly alcohol consumption and higher body mass index were marginally associated with circulating OT levels. Even after including health behaviors in the model, couples' positive behaviors were still significantly related to OT. In the AVP model, sleep was marginally associated with the peptide plasma levels. Both negative behaviors during the marital interaction and self-reported negative marital interactions were significant predictors of AVP, even after adjusting for differences in health behaviors.

Impact of the Perception of Support During the Marital Interaction Task

Some authors have argued that the relationship between marital quality and OT plasma levels might vary during periods of stress (Taylor, 2006). To make sure that this possibility did not confound our results, the models for OT and AVP were re-run with a sample excluding the 4 individuals who did not perceived their dyadic interaction as socially supportive. Results showed that couples' positive behaviors remained a significant predictor of OT plasma levels, $t(57) = 2.12, p = .04$. Similarly, couples' negative behaviors, $t(59) = -2.20, p = .03$ still significantly predicted plasma levels of AVP and the TENSE was marginally associated with the peptide, $t(59) = -1.89, p = .06$. This suggests that even after excluding couples who did not experience the discussion as socially supportive the relationship between marital quality and plasma levels of these peptides remained the same.

CHAPTER 4

DISCUSSION

Oxytocin and vasopressin are neuropeptides that have been associated with social bonding in animal and human studies. This study investigated the relationships between OT and AVP plasma levels and behavioral and self-reported indicators of marital quality. Results showed that OT was positively associated with the frequency of positive behaviors during a marital interaction task, while AVP was negatively associated with the frequency of negative behaviors during marital interaction and with self-reported negative marital interactions in the past month. Neither OT nor AVP was associated with self-reported marital satisfaction.

Lack of Change Over Time in Plasma OT and AVP

Plasma levels of OT and AVP did not change over the course of the visit at the CRC. The baseline sample was collected around 7:45 AM and the second sample was drawn at 12:00 PM, immediately after the end of the relationship history task. Given that there are no marked circadian fluctuations in OT in the morning, this suggests that neither the blistering procedure, the structured social support task, nor the relationship history task elicited prolonged changes in circulating OT and AVP levels. In accord

with our results, previous studies sampling OT immediately before and after a social interaction or a stress task in laboratory have not observed changes in plasma OT up to one hour after the experimental manipulation (Ditzen et al., 2007; Grewen et al., 2005; Taylor et al., 2006). In this context, positive and negative behaviors during the marital interaction were not likely to drive changes in OT and AVP plasma levels, but rather mirrored the overall quality of the relationship (Jacobson, 1979). The quality of the relationship might in turn be associated with circulating levels of the aforementioned neuropeptides.

Marital Quality and OT

A positive association was found between OT plasma levels and positive behaviors during the marital interaction task. These results are in accord with a series of studies reporting positive associations between indicators of marital quality and OT plasma levels (Grewen et al., 2005; Light, Grewen, & Amico, 2005). These data are also consistent with a growing body of literature showing that OT plasma levels are related to greater marital and non-marital relationship quality (Gordon et al., 2008; Light et al., 2004; Tops et al., 2007). Moreover, the positive association between positive behaviors and OT is in line with animal studies implicating OT in social bonding and long-term partner preferences (Cho et al., 1999; Kendrick et al., 1987). Furthermore, these results were observed despite the wide age range included in our sample and the marginally significant association of age with OT.

Marital Quality and AVP

Although in animal studies both OT and AVP have been associated with social bonding (Cho et al., 1999), to date no human study has looked at the relationship between relationship quality and AVP plasma levels. Our results show that AVP plasma levels were significantly related to negative behaviors during the marital interaction task and to the frequency of negative marital interactions in the past month. Participants who had lower levels of negative marital interactions had greater AVP plasma levels than individuals with higher levels of negative interactions. Observational and self-reported data thus converge in showing that negative behaviors are negatively related to circulating AVP levels. These results are in accord with animal studies showing that both OT and AVP are linked to social bonding and sociability (Cho et al., 1999; Landgraf et al., 2003). Recent human studies also report associations between polymorphisms of the AVP receptor 1A and marital bonding (Walum et al., 2008) and between early relationship quality and AVP plasma levels (Fries et al., 2005).

Positive and Negative Marital Behaviors and OT and AVP

Although both OT and AVP were associated with marital behaviors during the interaction task, the pattern of associations with each kind of behavior differed between the two hormones. Positive behaviors were associated with OT, while negative behaviors were related to AVP. Differences in the localization of OT and AVP receptors in the brain may explain the different patterns of associations of these peptides with positive and negative behaviors.

Several studies suggest that OT is associated with prosocial and approach behaviors. For example, OT plasma levels covaried with prosocial behaviors during

experimental economics games and intranasal OT administration increased trust and generosity in these tasks (Kosfeld et al., 2005; Zak et al., 2005; Zak et al., 2007). Furthermore, intranasal OT administration before the discussion of a marital disagreement led to a higher ratio of positive to negative behaviors during the interaction task, compared to the placebo administration (Ditzen et al., 2008). These data are in line with studies suggesting that OT modulates the activity of neurobiological systems involved in approach behaviors and reward and may partly underlie the reinforcing value of social relationships (Lim & Young, 2006).

In contrast, AVP has been linked with defensive behaviors (Caldwell et al., 2008). In animal studies, AVP has been implicated with offensive aggression, especially inter-male aggression (Blanchard et al., 2005). Furthermore, AVP has been related to stress, anxiety, and depression (Frank & Landgraf, 2008). This led some theorists to suggest that AVP may be implicated in the neurobiological system involved in fight or flight responses (Porges, 2001), potentially explaining why plasma AVP levels are associated with negative, but not positive marital behaviors.

Direction of the Relationship Between Marital Quality and Nanopeptides

While the results of our study revealing positive associations between relationship quality and OT and AVP are consistent with other human studies with married couples (Grewen et al., 2005), they also contrast with some human and animal data showing that chronic social stress or social isolation may increase circulating OT (Grippe et al., 2007; Taylor et al., 2006). The reasons for the discrepancy between these studies are unclear. Human studies that have reported positive relationships between marital quality and OT plasma levels included supportive social interaction

or non-noxious physical contacts. For example, among couples who underwent a warm touch intervention and mothers who were asked to hold their baby before a laboratory task, a positive association was observed between relationship quality and OT plasma levels (Grewen et al., 2005; Light, Grewen, & Amico, 2005; Light et al., 2004). In contrast, among women who participated alone in a stressful laboratory task, OT was negatively associated with marital quality. This suggests that the stressful or socially supportive context of the study may influence the direction of the relationship between marital quality and OT (Taylor, 2006).

Alternatively, sample and methodological differences between studies may also explain the discrepant results. The Taylor et al., (2006) study comprised both single and married women and no statistical adjustments were made to account for differences in relationship status despite its impact on OT plasma levels (Turner et al., 1999). Moreover, the quality of social relationships was evaluated via non-standardized instruments and portions of the questionnaire were used for single item analyses.

In accord with studies with married couples in a socially supportive context, positive relationships between marital quality and OT and AVP plasma levels were observed in our sample. To increase confidence in our results, the analyses were also conducted after excluding participants who did not perceive their marital interaction as socially supportive. Even when these participants were excluded, the relationships between marital quality and OT and AVP plasma levels remained positive. Moreover, both behavioral indicators and a standardized questionnaire of marital quality concurred in showing positive associations between plasma OT levels and marital quality. Collectively, these results provide further evidence of a positive relationship

between marital quality and peptides among married couples engaging in a socially supportive interaction.

Self-Reported Marital Satisfaction and OT and AVP

The MAT, a self-report questionnaire assessing subjective marital satisfaction, was neither associated with OT nor with AVP plasma levels. Similar to our results, Ditzen et al., (2007) reported that relationship satisfaction was not significantly associated with basal and OT reactivity to stress. These results contrast with the hypotheses that marital quality would be associated with circulating peptide levels. Several authors have argued that the concept of marital quality is multidimensional (Hassebrauck & Fehr, 2002). The fact that self-reported negative marital interactions, but not marital satisfaction were associated with AVP suggests that only certain dimensions of marital quality might be associated with peptides plasma levels.

Previous studies suggest that partner support as defined by the spouse's helpfulness in providing emotional, tangible, and informational support may be a dimension of relationship quality that is related to plasma peptides (Grewen et al., 2005). Furthermore, physical intimacy as assessed by the frequency of partner hugs and massage was also associated with OT plasma levels. These data suggest that at least some dimensions of the construct of marital quality are related to circulating peptides. However, the current study included only three indicators of marital quality that are unlikely to provide a comprehensive assessment of the construct. Fletcher, Simpson, & Thomas (2000) proposes a model of relationship quality comprising 6 dimensions: satisfaction, commitment, intimacy, trust, love, and passion. Using such

conceptual model, future research may be able to determine more specifically which dimensions of marital quality are related to OT and AVP plasma levels.

Relationship between the TENSE, Negative Behaviors, and AVP

Both self-reported and observed negative behaviors were significant predictors of AVP. Although the Spearman's rho correlation showed a significant association between the two variables, the zero-order correlation between the dichotomized TENSE and negative behavior variables was not significantly different from zero. This suggests that the two variables contributed independently to the prediction of AVP plasma levels.

Observed negative behaviors during a marital interaction task provide measurements of marital quality that are not biased by social desirability or lack of awareness of marital interaction patterns; these observations have been associated with cross-sectional and longitudinal marital outcomes (Bradbury & Karney, 2004). Perceptions of the frequency of negative marital behaviors also appear to be an important determinant of marital quality and marital outcomes. In fact, adding self-report measures of marital conflict to observed behavioral data improved the prediction of longitudinal marital outcomes (Rogge & Bradbury, 1999). Similarly, perceptions of communication patterns also influenced cortisol responses during actual marital conflict (Heffner et al., 2006). These data are in accord with cognitive-behavioral models of marital quality emphasizing the importance of both actual behaviors and the individual's subjective appraisal of negative interactions in the determination of marital quality (Bradbury, 1991).

Gender differences in the relationships between marital quality and AVP

We hypothesized that gender would moderate the association between AVP and marital quality. The moderation effect, however, was not supported by our data. Although previous studies have found sexually dimorphic associations between AVP and social behaviors, the lack of a moderating impact of gender might be due to the different levels of analysis evaluated in the present study. Previous studies have found that intranasal administration had sexually dimorphic effects on facial expression and perception of friendliness of facial stimuli (Thompson et al., 2004; Thompson et al., 2006). However, pharmacological doses of AVP may have a different impact than endogenous production of the hormone. Similarly, AVP receptor 1A polymorphisms were associated with poor marital quality for men, but not for women. Several factors involved in the integrity of the vasopressinergic system may explain the lack of concordance between genotype and plasma AVP.

Marital Quality, Health Behaviors, OT, and AVP

Health behaviors are known to influence a wide range of physiological functions (Kiecolt-Glaser & Glaser, 1988a). In addition, stress, including marital stress, impacts these health behaviors (Kiecolt-Glaser & Newton, 2001). It is therefore important to account for differences in health behaviors when evaluating the relationship between psychological characteristics and immune or endocrine functioning (Kiecolt-Glaser et al., 1988). Our results show that positive and negative behaviors remained significantly associated respectively with OT and AVP plasma levels, even after accounting for differences in health behaviors.

Estrogen enhances the biological action of OT and is used in animal studies to investigate the role of OT in social behaviors (McCarthy, 1995). In humans, hormone replacement therapy also increases OT plasma levels in some women (Light, Grewen et al., 2005). However, Taylor et al., (2006) reported that women using unopposed estrogen, but not women using a combined estrogen and progesterone compound, had higher OT levels than women not on hormone replacement therapy. In our study, estrogen supplementation was not significantly associated with OT plasma levels. However, only two women were taking unopposed estrogen and the other eight were taking combined estrogen and progesterone compound. The use of progesterone supplementation may explain why we did not observe a significant association between estrogen use and OT plasma levels.

Strengths and Limitations of the Study

The use of behavioral and self-report data to assess marital quality is a strength of the study because our results are unlikely to be affected by common method variance. Furthermore, the inclusion of married couples with a wide distribution of marital satisfaction maximized our chance of detecting the hypothesized effects. A limitation of the study is the fact that we only had two blood samples taken 4 hours apart for OT and AVP analysis. Multiple OT and AVP measurements immediately before and after the marital interaction task would have provided a better test of the impact of this experimental manipulation on peptide levels. These peptides are metabolized within minutes and might have returned to baseline levels by the time our second sample was taken. Furthermore, it is unclear to what extent peripheral OT and AVP measures are related to brain levels of these peptides. Our results showing that

the social interaction task did not elicit changes in OT and AVP plasma does not preclude the possibility that the task induced central release of these peptides. Moreover, the dichotomization of the variables due to the relatively low frequency of observed and self-reported negative marital behaviors decreased our power to detect significant zero-order correlations between the independent and dependent variables. In addition, when multiple variables in a given model are dichotomized, an increased risk of obtaining spurious findings is also observed (MacCallum, Zhang, Preacher, & Rucker, 2002). Another limitation of this study is its relatively small sample size given the effects of the relationship between marital quality and peptides.

Conclusion and Future Directions

In summary, behavioral indicators of marital quality were positively related to both OT and AVP plasma levels among married couples participating in a socially supportive marital interaction task. This study adds to the literature reporting positive association between relationship quality and plasma OT levels in non-stressful situation. Overall, this study extends the results observed in animal studies that both OT and AVP are implicated in social bonding.

In order to provide an adequate test of the hypothesis that the direction of the relationship between marital quality and circulating peptides levels vary during periods of stress, future studies should include both a supportive interaction task with the spouse and a stressful laboratory task without the spouse. Furthermore, the use of a marital conflict task in addition to the social support task and recruitment of more individuals in a distressed relationship may help in obtaining greater variability in both observed and self-reported negative behaviors. Moreover, although

methodologically challenging, assessment of CSF OT and AVP levels would help clarify the relationships among social interaction, stress, and peptides production and would help bridge the human and animal literature on social bonding and peptides. Finally, several authors have speculated that changes in OT and AVP associated with social relationship may mediate the positive influence on health . Future studies should aim to evaluate how relationship-induced changes in peptides modulate physiological stress responses.

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APPENDIX A

TABLES

	Frequency	Percentage
Gender		
Male	34	49.3
Female	35	50.7
Ethnicity		
Caucasian	63	91.3
Hispanic	2	2.9
African-American	3	4.3
Asian	1	1.4
Education		
High School	12	17.4
Some College	18	26.1
College Graduate	27	39.1
Graduate or Professional Training	12	17.4
Income (\$)		
< 20 000	23	33.33
20 001 –30 000	13	18.84
30 001-40 000	12	17.39
40 001-50 000	7	10.14
50 001-60 000	6	8.7
> 60 001	7	10.14

Table 1. Participants' Sociodemographic Characteristics

	Mean	Median	Standard deviation	Minimum	Maximum
Caffeine use (cups/day)	1.88	2	1.52	0	6
Alcohol use (drink/week)	1	0	2.41	0	15
Exercise (hours/week)	2.45	2	1.93	0	7
BMI (kg/m²)	28.98	28.57	5.16	19.44	41.68
Sleep Quality	5.49	5	2.34	1	12.25

Table 2. Descriptive Statistics of Participants' Health Behaviors

	<i>Mean</i>	<i>Median</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>
OT	324.80	245.78	242.66	79.97	1108.12
AVP	77.53	56.81	63.23	9.73	291.03
MAT	114.20	115	24.73	39	155
TENSE	1.99	1.15	2.36	0	11.65
Positive behaviors	19.03	14	11.22	2	41
Negative behaviors	4.22	2	5.08	0	20

Table 3. Descriptive Statistics of Nanopeptides and Marital Quality Variables

	OT	AVP	MAT	TENSE	Positive Behaviors	Negative Behaviors
OT	1	.31**	.07	-.24**	.21*	-.01
AVP		1	.07	-.30**	.06	-.24**
MAT			1	-.42**	.33**	-.08
TENSE				1	-.09	.30**
Positive behaviors					1	-.01
Negative behaviors						1

* $p < .10$, ** $p < .05$

Table 4. Spearman's Rho Correlations Between Marital Quality and Nanopeptides

	OT	AVP	MAT	TENSE	Positive Behaviors	Negative Behaviors
OT	1	.22*	-.06	-.16	.21*	.03
AVP		1	.12	-.24**	.05	-.28**
MAT			1	-.36**	.27**	-.15
TENSE				1	-.04	-.06
Positive behaviors					1	.13
Negative behaviors						1

* $p < .10$, ** $p < .05$

Table 5. Zero-Order Correlations Between Marital Quality and Nanopeptides

	Estimate	Standard Error	<i>t</i>(df)	<i>p</i>-value
Intercept	2.56	.067	38.13 (61)	< .001
Gender	-.180	.066	-2.73 (61)	.009
Age	-.005	.003	-1.78 (61)	.08
Estrogen	.135	.102	1.33 (60)	.19
MAT	-.001	.002	.82 (61)	.42
TENSE	-.100	.072	1.38 (61)	.17
Positive behaviors	.008	.003	2.58 (61)	.01
Negative behaviors	-.048	.066	-.72 (61)	.73

Table 6. Estimation of the Individual-Level and Couple-Level Predictors of Plasma OT

	Estimate	Standard Error	<i>t</i>(df)	<i>p</i>-value
Intercept	1.97	.07	28.11 (63)	< .001
Gender	-.09	.07	-1.35 (63)	.18
MAT	.0001	.002	-.52 (63)	.61
TENSE	-.156	.07	-2.09 (63)	.04
Positive behaviors	.003	.003	.78 (63)	.63
Negative behaviors	-.0155	.07	-2.20 (63)	.03

Table 7. Estimation of the Individual-Level and Couple-Level Predictors of Plasma AVP

	Estimate	Standard Error	<i>t</i>(df)	<i>p</i>-value
Intercept	1.97	.080	23.50 (59)	< .001
Gender	-.070	.120	-.57 (59)	.57
MAT	.0004	.002	-.20 (59)	.83
TENSE	-.111	.106	-1.06 (59)	.29
Positive behaviors	.005	.005	1.02 (59)	.31
Negative behaviors	-.190	.100	-1.92 (59)	.06
MAT x Gender	.001	.003	-.24 (59)	.81
TENSE x Gender	-.113	.152	-.74 (59)	.46
Positive behaviors x Gender	-.005	.007	-.80 (59)	.43
Negative behaviors x Gender	.065	.140	.46 (59)	.65

Table 8. Estimation of the Gender Moderation Effect for the AVP Model

	Estimate	Standard Error	<i>t</i>(df)	<i>p</i>-value
Intercept	2.50	.080	33.13 (54)	< .001
Gender	-.19	.069	-2.79 (54)	.007
Age	-.007	.003	-2.46 (54)	.017
Estrogen	.15	.099	1.51 (54)	.136
MAT	-.002	.001	-1.41 (54)	.165
TENSE	-.12	.072	-1.70 (54)	.095
Positive behaviors	.011	.003	3.30 (54)	.002
Negative behaviors	-.046	.067	-0.68 (54)	.501
Caffeine Use	-.029	.024	-1.23 (54)	.225
Alcohol Use	-.164	.081	2.01 (54)	.049
Exercise	-.020	.018	-1.16 (54)	.252
BMI	.010	.006	1.69 (54)	.096
Sleep	.006	.014	0.39 (54)	.694

Table 9. Estimation of the OT Model Including Health Behaviors Variables

	Estimate	Standard Error	<i>t</i>(df)	<i>p</i>-value
Intercept	2.01	.080	24.31 (57)	< .001
Gender	-.10	.068	-1.45 (57)	.15
MAT	.001	.002	-.35 (57)	.73
TENSE	-.185	.079	-2.35 (57)	.02
Positive behaviors	.002	.004	.68 (57)	.50
Negative behaviors	-.168	.074	-2.29 (57)	.03
Caffeine Use	-.019	.026	-.75 (57)	.46
Alcohol Use	-.030	.089	-.33 (57)	.75
Exercise	.020	.019	1.08 (57)	.28
BMI	.001	.006	.09 (57)	.93
Sleep	.030	.016	1.90 (57)	.06

Table 10. Estimation of the AVP Model Including Health Behaviors Variables

APPENDIX B

FIGURES

Figure 1. Oxytocin Plasma Levels As a Function of Couples' Positive Behaviors

Figure 2. Vasopressin Plasma Levels As a Function of Couples' Negative Behaviors

Figure 3. Vasopressin Plasma Levels As a Function of the Frequency of Negative Marital Interactions in the Past Month

APPENDIX C

MARITAL INTERACTION CODING SYSTEM

Rapid Marital Interaction Coding System
 Ver. 1.7, July, 2000
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Glossary

Baseline	Normative behavior for a particular couple. The typical “interactional style” of a couple.
Floor	The person who is speaking is said to be “holding the floor.”
Floor switch	Change in speaker; speaker gives up the floor to the partner.
Hierarchy	Order of importance of codes. Used to choose most important code when several codeable behaviors are emitted in one speaker turn.
Listener	Person who does not hold the floor.
Listener Backchannel	Verbal and nonverbal behaviors that merely indicate the listener is attending to the speaker. These behaviors are not coded directly (since the default listener code is “attention”).
Metacommunication	Communication about the communication process.
RMICS	Rapid Marital Interaction Coding System
Speaker	Person who has the floor
Speaker turn	Basic coding unit. Ends when a) floor switch occurs; b) when speaker talks for over 30 seconds, in which case speaker turn equals 30 seconds.
Successful Interrupt	The listener breaks into the speaker’s conversation and successfully takes the floor.
Unsuccessful Interrupt	The listener breaks into the speaker’s conversation but does not successfully take the floor. Any codeable behavior by the listener is coded, but is input as listener behavior.

Codes (listed in hierarchical order)

PA	Psychological Abuse
DA	Distress Maintaining Attribution
HO	Hostility
DY	Dysphoric Affect
WI	Withdrawal
AC	Acceptance
RA	Relationship Enhancing Attribution
SD	Self-Disclosure - Neutral or positive
HM	Humor
PD	Constructive Problem Discussion/Solution
OT	Other

Psychological Abuse (PA)

PA is defined as "a communication intended to cause psychological pain to another person, or a communication perceived as having that intent" (Vissing et al., 1991, p. 225).

Context is especially important when coding PA. The cultural context is one such element: individualistic PA involves a personal attack on the spouse (e.g., belittling, mocking), whereas collectivist PA involves attacking a cultural group with which the victim closely identifies (e.g., "Your family is a bunch of morons" "I hate Jehovah's Witnesses" [when the partner is a Jehovah's Witness]).

Verbal PA comprises:

- Disgust
 - "You make me sick." "Why would I want to have sex with you."
- Contempt / belittling / mocking
 - "You're a lousy father."
 - "You couldn't balance the checkbook if you tried, genius."
 - "Aww, you poor thing."
- Belligerence
 - "What are you going do about Huh Huh"
 - "Anytime you want to have a go at me, I'm ready."
- Threats
 - "Don't push me. You know what happens when push my buttons." (Said in a threatening manner.)
- Domineering
 - "Playing "district attorney".
 - "Look, I'm the one who makes the decisions around here. Don't talk back."
- Devaluing / negating partner's opinions or ideas (not simply disagreeing)
 - "That's a stupid idea."
 - "When you tell me your ideas about budgeting it makes me want to laugh."
- "Gaslighting" partner - Named after a famous movie starring Ingrid Bergman, where her husband tried to make her think she was going crazy. Gaslighting involves statements that the partner's basic instincts or perceptions are wrong, or that the partner couldn't possibly function alone.
 - "What do you mean I beat you up last month I've never laid a finger on you."
 - "How can you possibly be sad You have nothing to be sad about."
- PA can also be coded for nonverbal behaviors, such as:
 - glowering
 - physically intimidating (e.g., leaning into partner's physical space, smacking fist into hand)
 - pounding fists
 - talking very quietly or through one's teeth, in a threatening or menacing manner

Attributions

Attributions are the basic explanations that people give regarding the factors that cause a particular event. Attribution statements will often contain “because.” The RMICS codes two types of attributions — distress maintaining and relationship enhancing. The DA/RA distinction is derived from Holtzworth–Munroe & Jacobson (1988).

Method for Coding Attributions

1. Identify event (can be behavior, thought, or feeling) that is being explained.
2. Is that event negative or nonnegative?
3. Is the person whose behavior is being explained one of the spouses? (If no, not coded as an attribution)

Table for Coding Attributions

	Internal Intentional Responsible Global (Personality) Stable	External Unintentional Not responsible Specific (Behavior) Unstable
Event being explained		
–	DA	RA
+/0	RA	DA

Distress–Maintaining Attributions (DA)

DAs are negative causal explanations.

- DAs explain negative behaviors as due to personality traits, or to voluntary or intentional causes. DAs explain positive behaviors as due to circumstances, or to involuntary or unintentional causes.
- A DA that is a self-derogatory statement is not a DA, but is coded as a DY. For example, “we can’t afford to send the kids to camp because I am too stupid to get a good job” (said with sad voice tone).

EXAMPLES

1. “You were being mean on purpose.” [DA]
2. “We’re broke because we never stick to our budget” [DA]
3. “I didn’t clean up because I didn’t feel like it.” [DA]
4. “You’re only being nice so that I’ll have sex with you tonight.” [DA]
5. “I always feel like I’m on a leash when I’m coming home from work because if I’m not there within 15 minutes you’re waiting for me at the door ready to bawl me out.” (Irritated voice tone) [DA]
6. “You did that intentionally.” [DA]
7. “We are having problems because I am incapable of maintaining a good relationship.” [DY]

Relationship-Enhancing Attributions (RA)

RAs are positive causal explanations.

◦RAs explain negative behaviors as due circumstances, or to involuntary or unintentional causes. RAs explain positive behaviors as due to personality traits, or to voluntary or intentional causes.

EXAMPLES

1. "You're short with me because you've had a hard day." [RA]
2. "I was mad because your boss kept you late at work." [RA]

Notes

1. Responses to the partner that are reasons for behavior are coded as attributions, even if the full attributional phrasing is not used in the subsequent responses.

H: "I'm not going back to school because I haven't saved enough." [RA]

W: "You're chickening out." [DA]

H: "Can't afford it." [RA]

W: "Chickening out." [DA]

2. Words often associated with attributions

Easy

Because

Intentionally

On purpose

The reason why

Hard

Since (e.g., "Since you had a hard day at work, you took it out on me.")

So (e.g., "You had a hard day at work, so you took it out on me.")

Hostility (HO)

Hostility comprises all negative affect, and statements with a negative content. The RMICS hostility code comprises the following MICS codes:

- Turn Off — a nonverbal response which communicates hostility, displeasure, disapproval, or disagreement, and is usually in reaction to something the other partner is saying or has just said.
- Negative voice tone — Hostile voice tone that accompanies nonnegative statements.
- Criticize — dislike or disapproval of the other's behavior.
- Negative mindread — Negative inferences and assumptions made by one person about the spouse, including thoughts, beliefs, and intents that are not offered as attributions.
- Disagree — Disagreements said with negative affect or that do not further the discussion.
Note that disagreements that further discussion or explain a partner's point of view in a nonnegative way are coded as PD.

Examples of how to code disagreements that do not further a discussion:

1. I think we should go to the movies tonight [PD]
2. I don't think we should [PD]
3. Well I do [HO]
4. Well I don't [HO]

EXAMPLES

Non-verbal

1. Sour look
2. Negative/hostile voice tone
3. Rolls eyes dramatically
4. Turn quickly away from partner
5. Sigh deeply (intended as criticism, not as depressed affect)
6. Exaggerated gasp

Verbal

1. "The problem is your drinking."
2. "I don't give a damn what you think."
3. "You think that I'm a lousy mother."
4. "You're messy."
5. "You're careless about the money."
6. "You never listen to me."

Coders should attempt to adjust their coding to the baseline interactional style of the couple. For examples, for some couples, loud speaking is a discussion style, rather than a sign of hostility. For these couples, their typical style would be coded as PD. For others, loud speaking is a clear break from their typical style and therefore would be coded as HO. On the other hand, couples that are nasty from the beginning of the interaction should be coded as HO throughout — blatant hostility is not an interactional style. During training, it is important for coders to calibrate their threshold for hostility with the trainer and other coders.

Dysphoric Affect (DY)

Dysphoric Affect describes sad or depressed expressed emotional states.

Any of the following four conditions should be coded as DY:

1. Self-Complaints — DY is coded for any self-statement that indicates the subject has experienced, is currently experiencing or will experience some negative condition. Negative conditions can refer to physical problems, psychological problems, or a degrading / derogatory self-evaluation. Self-complaints of a psychological nature can be expressed in such specific terms as fear, anger, depression, or anxiety, or they can be expressed using more global terms \ such as down, grumpy, out of it, spacey, irritable.

2. Whiny voice tone

3. Dysphoric (Sad) Affect— Affect communicating sadness, despondency, or depression. Crying and tearfulness are included in DY. Persons who communicate dysphoric affect may show signs of sadness or distress such as speaking in a low, slow tone, becoming tearful, and verbally expressing their sadness.

4. A DA that is a self-derogatory statement is not a DA, but is coded as a DY. For example, “we can’t afford to send the kids to camp because I am too stupid to get a good job” (said with sad voice tone).

Adjectives that describe DY include the following:

Dejected	Melancholy
Depressed	Morose
Despondent	Discouraged
Sad	Sulky
Downhearted	Sullen
Downtrodden	Tearful
Glum	

Vocal cues include the following:

1. slow pace of speech
2. low, monotone voice
3. Cracked voice

Bodily nonverbal cues include the following:

1. heavy sighing
2. withdrawal (supersedes WI, but only when overt signs of sadness accompany the withdrawal and predominate)
3. low activity rate (e.g., sitting on a couch staring, extremely slow but fluid movements while completing an action)
4. appears to be extremely tired or listless

Withdrawal (WI)

WI is coded for behaviors that imply pulling back from the interaction, walling off the partner, or not listening to the speaker. Withdrawal does not consist of any one behavior, nor is it cued by any set cluster of behaviors or affective signs. Rather, the coder must make a judgment, based on the flow of the conversation and the verbal and nonverbal cues, if someone is withdrawing. WI can be used as either a speaker or listener code. A verbal WI is when one partner expresses a desire to end the discussion in a non-neutral voice tone.

The following are cues to non-verbal WI:

1. Closed-off body language (e.g., folded arms, moving body away from partner), especially when there is a change from a more open position during a turning point in a discussion.
2. Failure to respond (verbally or nonverbally) to the partner's question.
3. Muscular tenseness and/or rigidity.
4. Facial and verbal indications of holding back emotions
5. Nonverbal expressions that indicate that the listener is not listening (e.g., no eye contact, direct but glazed eye contact, turning away from speaker).
6. A sudden decrease in listener backchannel behaviors.

EXAMPLES

Verbal

1. "I don't want to discuss it anymore!"
2. "Oh god, I'm not going to listen to this."
3. "Sure...you're right...you're right." (When meant to block discussion and "shut up" partner)

Non-verbal

1. Husband rolls eyes and picks up chair, moves chair away from wife, and sits facing away from her.
2. Wife turns away, breaking eye contact, and makes no movements.
3. Wife doesn't talk or respond to husband in any way.
4. Husband does not respond to a question.
5. Husband is attending but has no movement and lacks facial expressions. He is very tense and has a "glazed" look in his eyes.
6. Wife looks down and fidgets, her body movements indicative of uneasiness.
7. Husband stops listener backchannel behaviors and shows signs of muscular tenseness and rigidity.

Acceptance (AC)

Acceptance comprises active listening skills that help the partner feel understood and validated.

This code includes all utterances that demonstrate understanding and acceptance of the partner. AC is characterized by the speaker trying to put her/himself in the partner's place, so s/he can comprehend the other's feelings and emotions better.

AC includes statements that involve paraphrasing (Restating partner's statement in your own words) and reflecting feelings (voicing what you thought the partner's underlying feelings were), giving positive feedback, and expressing caring, concern, or understanding of the partner's experience.

EXAMPLES

1. "So my untidiness is a real problem to you." [AC]
2. "...And that depressed you?" (said with caring tone) [AC]
3. "I like how you have been handling the kids lately." [AC]
4. "I could imagine that you would be sad now." [AC]
5. "Why did you take that road?" [PD]
6. "Do you want to go now?" [PD]
7. "I don't blame you for being tired and wanting to go." [AC]
8. "Thank you, that helped." [AC]
9. "You are really helpful." [AC]
10. "It was a good thing for you to do." [AC]

NOTES

The paraphrase or reflection need not be correct, as long as it appears that a good faith attempt at understanding was being made.

Self-Disclosure (SD)

Self-Disclosures are statements about the speaker's feelings, wishes or beliefs. Generally, SDs include "I" statements, which should be either explicit or strongly implied. SDs should reveal something about the person. Moreover, if a speaker talks about a self-disclosure which occurred in the past, the self-disclosure is still coded as a SD.

1. Direct expressions of feelings are also coded as SDs. This includes all speech contributions which mention a positive or negative feeling by name. These can be feelings about specific things. Excluded are global negative feelings (e.g., anger, hate, dislike, disgust) expressed with "you" as an object and meant to hurt or criticize the receiver (these are coded as HO or PA). Also excluded are disclosures of depressive thoughts or feelings, which are coded as DY.

Examples

1. "I am always glad when we have company." [SD]
 2. "I don't care what you want." [HO]
 3. "I feel very uncomfortable when we are at your parents' house." [SD]
 4. "I'll never get it right." [DY]
 5. "I hate you." [PA]
 6. "You make me so angry." [HO]
2. Direct expressions of wishes, needs and interests, or statements that reveal something about the persons' opinions, beliefs, or values are also coded as SDs. These are often global statements.

Examples

1. "I would always rather go to the movies than go bowling." [SD]
2. "I want to enjoy more freedom." [SD]
3. "I feel it is our responsibility to pay for the damages." [SD]
4. "Money is a means to an end." [SD]
5. "I see Sunday night is the kind of night that I don't want to have to go out with somebody else." [SD]
6. "I believe that mothers should be home with her children." [SD]

3. If the possible SD includes a prediction or promise of one's future behavior, code problem discussion [PD].

Examples

1. "I'll love you more." [PD]
2. "I'll stand up to your parents." [PD]

4. If "should" is used, code as SD if it is about a general opinion, and code as PD if it is concrete and about a particular situation.

Examples

1. "I feel I should help Billy with his homework each night." [PD]
2. "I feel children should respect their parents." [SD]

Humor (HM)

Any statement that is clearly intended to be humorous will be coded HM. An HM is usually made in a lighthearted tone and is almost always accompanied by laughter from the person making the statement. Furthermore, HM statements will often (but not always) evoke laughter from the other. HM is also coded for each turn of a laugh or a smile (excluding nervous laughter or smiling). Humor with even slight undertones of sarcasm (directed at the spouse) is coded as HO; sarcastic humor that is mean or hurtful would be coded as PA.

HM comprises the following:

1. Outright jokes of the “one liner” variety.
2. Proposals that are clearly facetious solutions to the problem.
3. Statements that emphasize the humorous aspects of a situation or a problem.
4. Statements that present lighthearted criticism of the other in such a manner that it is also lightly received (e.g., “Oh, you silly goose!” or “You’re such a nut”).

EXAMPLES

1. “I think it’s time to buy that Concord jet we’ve always dreamed of.” [HM]
2. “I know, I’ll bet if we sold the kids and moved to the moon we’d get some privacy.” [HM]
3. “We were so drunk we didn’t know if we were lost or the neighbor repainted his house.” [HM]
4. “Don’t worry about who’ll cook; we’ll just eat out every night!” (said in joking manner) [HM]
5. “Let’s shave our heads and sell flowers at the airport for extra income.” [HM]

Constructive Problem Discussion / Solution (PD)

This code comprises all constructive approaches to discussing or solving problems. The RMICS code comprises the following codes:

- Problem Description (both Problem Description–Internal & Problem Description–External)
- Constructive solutions. All proposals of constructive plans/contracts to solve problems. The MICS originally defined two solution codes:
- Positive Solution – Suggestions for problem resolution that entail increases in the target behavior.
- Negative Solution – Suggestions for problem resolution that entail decreases in the target behavior.
- Question – Verbal inquiries toward the partner.
- Agreement – Verbal or nonverbal signs of accord.

EXAMPLES

1. “I think we should start saving more money.” [PD]
2. “You should go out more often.” [PD]
3. “Let’s stop eating out so often.” [PD]
4. “When are the kids going to camp?” [PD]
5. “Tony really has a problem with his drinking.” [PD]
6. “We’re having a hard time with the kids.” [PD]
7. “I think you’re right about that.” [PD]
8. “Wives need to go out with their friends.” [SD]

Notes

“Solutions” can also be forms of hostility when they are not offered as constructive ways of mutually resolving the problem. Ex: “Why don't you do all of the housework for a change.” (HO)

Other (OT)

OT is most often coded when the experimental situation itself is discussed. OT is coded conservatively; the statement must be clearly out of bounds. If the couple strays from the appointed topic, but is talking about anything relevant to their lives or marriage, use a richer code.

EXAMPLES

1. "Is that the camera?" [OT]
2. "I don't like the painting they have on the wall." [OT]
3. "How long has it been? Has it been 10 minutes yet?" [OT]
4. "I'm hungry. Do you want to go to McDonald's when we're done here?" [OT]
5. (The topic is money) "But I think you're mother is a bigger problem. She's always butting into our lives." [PD]

Notes Not Pertaining to Specific Codes

1. Notes for the first few turns coded in an interaction:
 - a. When beginning to code an interaction, usually assume laughing and giggling is nervous laughter, not to be coded as HM
 - b. When beginning to code an interaction, for the majority of couples, code the first few turns as PD, unless another code is definitely more appropriate.
2. Notes for coding floor switches:
 - a. Unsuccessful interrupt — If one spouse is speaking (has the floor) and the other says something concurrently, but the one with the floor does not acknowledge the other (does not nod, pause, change direction of original comment, agrees, etc), then the spouse without the floor (the listener) gets a listener code.
 - It is important that the utterance made by the listener has meaning. If the coder cannot decipher what the listener said, or the listener stopped trying to interrupt before saying anything meaningful (e.g., yea-but...), listener codes are not given.
 - b. Successful interrupt — If one spouse is speaking (has the floor) and the other says something concurrently, and the one with the floor does not give up the floor (continues to speak) but does acknowledge the other (nods, changes direction of original comment, agrees, etc), then the one without the floor (the listener) gets the floor. The assumption here is that since the interruption has caused a reaction/change by the speaker, the interruption was successful.
 - c. Successful interrupt — If one spouse is speaking (has the floor) and the other says something concurrently, and the one with the floor stops talking, the spouse without the floor (the listener) gets the floor.

APPENDIX D

SELF-REPORT QUESTIONNAIRES

BACKGROUND QUESTIONNAIRE

1. What is your gender?
 - ☐ Male
 - ☐ Female
2. How old are you? _____
3. How long have you been married ? _____
4. Is this your first marriage?
 - ☐ Yes
 - ☐ No
5. Do you have any children or step-children?
If yes, how many? _____
6. What is the highest level of education you have completed?
 - ☐ Graduate or professional training
 - ☐ College or University graduate
 - ☐ Some college
 - ☐ High school Graduate
 - ☐ Some High School
7. What is your current annual income?
 - ☐ < 20 000
 - ☐ 20 001- 30 000
 - ☐ 30 001- 40 000
 - ☐ 41 001- 50 000
 - ☐ 51 001- 60 000
 - ☐ > 60 001
8. What race do you consider yourself to be?
 - ☐ American Indian or Alaskan
 - ☐ Black or African American
 - ☐ Asian, Asian American, or Pacific Islander
 - ☐ White or European (non-Hispanic)
 - ☐ Hispanic
 - ☐ Other : _____

HEALTH BEHAVIORS QUESTIONNAIRE

1. How many cups of caffeinated coffee or other caffeinated beverages do you usually drink per day? _____ cups

2. How many alcoholic drinks do you normally have in a week? (drink is defined as 12 oz can or bottle of beer or wine cooler, 4 oz glass of wine, shot of liquor straight or mixed) _____ drinks

3. At least once a week do you engage in any regular activity like brisk walking, jogging, bicycling, etc. long enough to build up a sweat?

☐ Yes ☐ No

If yes, how many days per week? _____

How many total hours per week? _____

4. Please list the medications, herbs, and dietary supplements (prescription and non-prescription) you are currently taking.

	<u>Name of the Medication</u>	<u>What are you taking it for?</u>	Prescription	Non-Prescription
1.			☐	☐
2.			☐	☐
3.			☐	☐
4.			☐	☐
5.			☐	☐
6.			☐	☐
7.			☐	☐
8.			☐	☐
9.			☐	☐
10.			☐	☐

PITTSBURG SLEEP QUALITY INDEX

The following questions relate to your usual sleep habits during the PAST MONTH ONLY.

1. What time have you usually gone to bed during the past month?

__:__ ☐ a.m. ☐ p.m.

2. How many minutes has it taken you to fall asleep each night during the past month?

_____ minutes

3. At what time have you usually gotten up in the morning during the past month?

__:__ ☐ a.m. ☐ p.m.

4. How many hours of actual sleep do you usually get on a typical night during the past month?

_____ hours

During the past month, how often have you trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	3 or more times a week
5a ...cannot get to sleep within 30 minutes				
5b ...wake up in the middle of the night or early morning?				
5c ...have to get up to use the bathroom?				
5d ...cannot breath comfortably?				
5e ...cough or snore loudly?				
5f ...feel too cold?				
5g ...feel too hot?				
5h ...have bad dreams?				
5i ...have pain?				
5j...other reasons (specify):_____				

6. During the past month, how often have you taken medicine (prescribed or over the counter) to help you sleep?

☐ Not during the past month

☐ Less than once a week

☐ Once or twice a week

☐ 3 or more times a week

7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

- ☐ Not during the past month
- ☐ Less than once a week
- ☐ Once or twice a week
- ☐ 3 or more times a week

8. During the past month, how much of a problem has it been for you to keep up your enthusiasm to get things done?

- ☐ Not during the past month
- ☐ Less than once a week
- ☐ Once or twice a week
- ☐ 3 or more times a week

9. How would you rate your sleep quality overall ?

- ☐ Very good
- ☐ Fairly good
- ☐ Fairly bad
- ☐ Very bad

TENSE – SPOUSE VERSION

The following survey concerns different types of **NEGATIVE INTERACTIONS** you might have had with **YOUR SPOUSE** over the **PAST MONTH**. Take a few moments to think about your interactions with your spouse over the past month. The use the scale listed beside each item to indicate how often you experienced each of the following types of negative interactions with your spouse during the past month.

	Not at all	Once or twice	About once a week	Several times a week	About every day
1. Ignored my wishes or needs.	☐	☐	☐	☐	☐
2. Yelled at me.	☐	☐	☐	☐	☐
3. Lost his or her temper with me.	☐	☐	☐	☐	☐
4. Invaded my privacy.	☐	☐	☐	☐	☐
5. Laughed at me.	☐	☐	☐	☐	☐
6. Prevented me from working on my goals.	☐	☐	☐	☐	☐
7. Disagreed with me.	☐	☐	☐	☐	☐
8. Was too demanding of my attention.	☐	☐	☐	☐	☐
9. Gossiped about me.	☐	☐	☐	☐	☐
10. Made fun of me.	☐	☐	☐	☐	☐
11. Nagged me.	☐	☐	☐	☐	☐
12. Was inconsiderate.	☐	☐	☐	☐	☐
13. Distracted me when I was doing something important	☐	☐	☐	☐	☐
14. Took me for granted.	☐	☐	☐	☐	☐
15. Took advantage of me.	☐	☐	☐	☐	☐
16. Was impatient with me.	☐	☐	☐	☐	☐
17. Took my feelings lightly.	☐	☐	☐	☐	☐
18. Was angry with me.	☐	☐	☐	☐	☐

MARITAL ADJUSTMENT TEST

1. Check the number on the scale line below which best describes the degree of happiness, everything considered, of your present marriage. The middle point happy, represents the degree of happiness which most people get from marriage, and the scale gradually ranges on one side to those few who are very unhappy in marriage, and on the other, to these few who experience extreme joy or felicity in marriage.

0	2	7	15	20	25	35
Very unhappy			Happy		Perfectly Happy	

State the approximate extent of agreement or disagreement between you and your partner on the following items.

	Always agree	Almost always agree	Occasionally agree	Frequently disagree	Almost always disagree	Always Disagree
2. Handling family finances	5	4	3	2	1	0
3. Matters of recreation	5	4	3	2	1	0
4. Demonstrations of Affection	8	6	4	2	1	0
5. Friends	5	4	3	2	1	0
6. Sex relations	15	12	9	4	1	0
7. Right, good, or proper conduct	5	4	3	2	1	0
8. Philosophy of life	5	4	3	2	1	0
9. Ways of dealing with in-laws	5	4	3	2	1	0

10. When you and your partner disagree, who usually gives in?
☐ Your partner ☐ You ☐ Or do you reach a compromise
11. How many outside interests so you and our spouse engage in together?
☐ All of them ☐ Some of them ☐ Very few of them ☐ None of them
12. In your leisure time do you most often to...
☐ Stay home ☐ Be on the go
 Does your spouse most often prefer to...
☐ Stay home ☐ Be on the go
13. How often do you wish that had never been married?
☐ Frequently ☐ Occasionally ☐ Rarely ☐ Never
14. If you had to live your life over. Do you think you would...
☐ Marry the same person ☐ Marry a different person ☐ Not marry at all
15. Do you confide in your husband...
☐ In everything ☐ In most thing ☐ Rarely ☐ Almost never

SATISFACTION WITH THE DISCUSSION

Please rate your reaction to the discussion you just finished.

1. How satisfied are you with the outcome of the discussion?

Not satisfied

Very Satisfied

1 2 3 4 5 6 7 8 9

2. To what degree were you and your spouse able to work productively on the problem in the discussion?

Not at all able

Very able

1 2 3 4 5 6 7 8 9

3. How much did you feel that you partner understood you?

Not at all

Completely

1 2 3 4 5 6 7 8 9

4. How much did you feel that your partner supported you?

Not at all

Completely

1 2 3 4 5 6 7 8 9