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# In search of an adult attachment stress provocation to measure effect on the oxytocin system: A pilot validation study

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## Abstract

**BACKGROUND—**Oxytocin is a promising biomarker for psychiatric conditions arising from early relational trauma, childhood maltreatment, and attachment dysregulation, including posttraumatic stress and dissociative disorders.

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**Author Contributions:** MM participated in the study design and coordination, carried out data collection, performed statistical analysis, and was involved in drafting and revising the manuscript. SB was principal investigator of the parent study, conceived of the add-on study, and was involved in drafting and revising the manuscript. HPN performed analysis of specimens and was involved in drafting and revising the laboratory methods section. CC oversaw analysis of specimens and was involved in drafting and revising the manuscript. WL participated in study coordination, carried out data collection, and was involved in drafting and revising the manuscript. JS conceived of the study, participated in its design and coordination, performed statistical analysis, and was involved in drafting and revising the manuscript. All authors read and approved the final manuscript.

The authors report no conflicts of interest or competing interests.

**OBJECTIVE—**This exploratory pilot study examined plasma oxytocin as a biomarker for alterations in the attachment system.

**DESIGN—**We used a single group, repeated-measures design with 15 women. The protocol used a film clip previously validated as a provocation to the hypothalamic–pituitary–adrenal axis.

**RESULTS—**The repeated-measures ANOVA showed differences in oxytocin across the three time points. Correlations with oxytocin indicated that measures of dissociation and somatization correlated most strongly with higher levels of oxytocin measured during exposure to the film's bonding scene and posttraumatic stress disorder correlated most strongly with lower levels at the film's abandonment scene. Post hoc analyses revealed differences in oxytocin response related to psychopathology.

**CONCLUSION—**Replication studies should characterize participants on a range of psychiatric conditions associated with attachment dysregulation.

**Keywords**

oxytocin; posttraumatic stress disorder (PTSD); biomarker; attachment; dissociation

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Oxytocin is a mammalian nonapeptide. It is a neurotransmitter secreted centrally by the pituitary gland and a paracrine hormone secreted broadly in the periphery. Oxytocin has numerous functions across biological, psychological, and social levels. It is implicated in parasympathetic regulation, including calm stress-recovery, immune responses and wound healing, growth, and vagal tone, as well as in smooth muscle regulation, including orgasm, uterine labor contractions, and milk ejection in lactation (Gouin et al., 2010; Porgess, 2011; Uvnas-Moberg, 2003). Oxytocin's function is often sexually dimorphic, likely both in relation to steroid hormones (Carter, Boone, Pournajafi-Nazarloo, & Bales, 2009) and gender socialization (Taylor, 2006).

A sizeable animal model literature implicates oxytocin as part of the neuroendocrine basis of social bonds, attachment, and love (Carter, 1998; Carter & Porges, 2011; Heinrichs, von Dawan, & Domes, 2009). Oxytocin has been implicated in the psychobiology of adult attachment in which secure attachment figures within an adult's life positively impact both physiological and emotional regulation (Diamond, 2001). Oxytocin is also involved in attachment behaviors including proximity-seeking and grooming (Drago, Pedersen, Caldwell, & Prange, 1986), social memory (Ferguson et al., 2000), reduced separation distress (e.g., Panksepp, Nelson, & Bekkedal, 1997), and secure-base phenomena, such as the exploration of a novel environment (e.g., McCarthy, Kow, & Pfaff, 1992). Additionally, oxytocin influences the initiation of partner preferences (Insel & Hulihan, 1995; Keverne, Nevison, & Martel, 1997; Williams, Insel, Harbaugh, & Carter, 1994) and stimulates the onset of maternal behavior in some species (e.g., Pedersen, 1997; Pedersen & Prange, 1979). Among humans, oxytocin is involved in social cues, trust, and prosocial behavior (Bartz & Hollander, 2006). Recent research also underscores oxytocin's role in a gene-by-environment effect in which social behaviors and human attachment are transferred between the mother-infant dyad via biological means and caregiving experiences (Feldman, Gordon, Influs, Gutbir, & Ebstein, 2013).

Recently, we have found evidence that there may be a connection between exposure to early relational trauma, childhood maltreatment, associated features found among maltreatment survivors with posttraumatic stress disorder (PTSD), and oxytocin levels. These associated features include (a) *dissociation* which describes an individual's detachment from emotional and physical experiences; (b) *somatization* or recurring physical complaints that interfere with an individual's daily life that cannot be explained by a medical condition; and (c) *interpersonal sensitivity* which refers to a heightened awareness of and reactivity to the behaviors and feelings of others (American Psychiatric Association, 1994). Depression, which is characterized by low mood and loss of pleasure, also is frequently comorbid with PTSD (American Psychiatric Association, 1994). A recent pilot study of oxytocin during pregnancy demonstrated, for example, that oxytocin levels among those with a history of trauma and associated PTSD were predicted by dissociation symptoms (Seng et al., 2013). This finding is consistent with the possible role that oxytocin dysregulation may have in relation to mental and physical health conditions in which insults to or deficits in interpersonal relations play a role, per the cascade theory (Teicher, Andersen, Polcari, Anderson, & Navalta, 2002) and the posttraumatic oxytocin dysregulation theory (Seng, 2010). Such conditions include posttraumatic spectrum disorders occurring subsequent to childhood trauma, including PTSD, dissociative and somatoform disorders, and borderline personality disorder (Teicher, Andersen, Polcari, Anderson, & Navalta, 2002). Oxytocin dysregulation also has been considered in relation to autism spectrum disorders (Carter et al., 2007; Porges, 2011). Further, oxytocin plays a role in intergenerational patterns of vulnerability in animal models (Meaney, 2001) and may do so in humans as well, since low maternal oxytocin levels in pregnancy have been associated with postpartum depression (Skrundz, Bolten, Nast, Hellhammer, & Meinlschmidt, 2011), a condition known to adversely affect maternal caregiving.

Our program of research focuses on trauma to the attachment system and resulting psychopathology including elements of the "complex" PTSD that can result from childhood maltreatment. For purposes of this study, we define that as PTSD *per se* plus any of the associated features of dissociation, somatization and interpersonal sensitivity, possibly complicated by depression comorbidity as well. The combination of these related elements has demonstrated an association with dysregulated oxytocin levels. For example, high or pulsatile oxytocin levels have been associated with trauma history, including childhood abuse (Pierrehumbert et al., 2010); trauma history and insecure attachment style (Pierrehumbert, Torrisi, Ansermet, Borghini, & Halfon, 2012); early relational trauma and complex PTSD (Seng, 2010; Seng et al., 2013), and depression in women (Cyranowski et al., 2008).

To the extent that oxytocin levels reflect both healthy attachment as well as impairment in the attachment system, it suggests that oxytocin levels may be a candidate biomarker to assess for individual differences in risk for clinical disorder. Thus far, individual differences in attachment have been studied primarily as they relate to a psychological sense of security (e.g., attachment style as secure versus insecure; Ainsworth, 1969, 1985), and empirical studies have not fully explored the biological basis for individual differences in attachment. In order to begin to examine whether oxytocin measures have the potential to assess clinically meaningful alterations in the attachment system, it is first necessary to establish

that (a) oxytocin is sensitive to attachment-related stimuli, and (b) individual differences in psychopathology symptoms that predict clinical disorder also produce different profiles of oxytocin responses to attachment stressors.

Our primary goal was to study whether (a) oxytocin is sensitive to attachment-related stimuli; we conducted an exploratory study with a non-clinical sample of college women to characterize the oxytocin response to an established laboratory protocol that manipulates "affiliation motivation," which we conceptualized to be a provocation to the attachment system. In hopes of beginning to also gather data about oxytocin levels in relation to (b) individual differences in psychopathology symptoms that predict clinical disorder, we included measures of symptoms of PTSD, associated features, and depression. This small study was added on to a social psychology experiment (described below) conducted with a community sample, so we were not able to select for psychopathology. However, given the prevalence of trauma and PTSD among women, we hoped to find some symptoms and perhaps a few cases. We used an "affiliation stress" protocol with established face validity (Wirth & Schultheiss, 2006) previously shown to provoke the hypothalamic-pituitary-adrenal axis using a half-hour segment from the film *Artificial Intelligence* (*AI*; Director Steven Spielberg, 2001). Wirth and Schultheiss (2006) verified that this affiliation stress caused cortisol reactivity, evident in statistically significant changes across the key time points. The key time points in the *AI* challenge include a positive (bonding) segment followed by a negative (abandonment) segment. We explored the following questions:

Research Question 1: Can differences in oxytocin levels be predicted by the type of attachment scene (bonding versus abandonment)?

Hypothesis 1: Oxytocin level will increase from baseline to bonding scene time point.

Hypothesis 2: Oxytocin level will decrease from baseline to abandonment scene time point.

Hypothesis 3: Oxytocin levels at bonding scene and abandonment scene time points will differ.

Hypothesis 4: There will be a main effect of protocol time point on oxytocin level.

Research Question 2: Do psychopathology symptoms related to trauma to the attachment system (i.e., PTSD, dissociation, interpersonal sensitivity, somatization, and depression) correlate with oxytocin levels?

Results of the above analyses led to a third research question which was examined with a *post hoc* analysis of selected cases.

Research Question 3: Do individual differences in psychopathology related to trauma to the attachment system predict individual differences in oxytocin response to the attachment scenes (bonding vs. abandonment)?

# Methods

## Design

The goals of this exploratory study, which we consider to be pilot work for future research, were to assess feasibility of the protocol and gather preliminary test-of-concept and effect size data. This study was appended to an NSF-funded social psychology experimental project (Award Number #0820609, PI, S. L. Brown, *Physiological Effects of Helping Others*) that involved repeated blood draws for oxytocin across a series of conditions. A subset (n=16) volunteered to extend their participation an additional half hour in order to complete the *AI* challenge protocol. One participant's intravenous access could not be maintained, so the final pilot sample included 15 women. Each woman served as her own control, with the bonding segment and abandonment segment considered in relation to her baseline (upon arrival to the lab) and in relation to each other.

## Recruitment and Participants

The parent study recruited a convenience sample at the University of Michigan using flyers and a research engagement webpage. It was advertised that participants would be paid. The study was explained to be a scientific study on social interactions. The parent study limited participation to females between the ages of 18 and 35. Due to the effects of steroid hormones on oxytocin levels, inclusion criteria were non-pregnant women on days 1–14 of their menstrual cycle. Exclusion criteria were smoking, using hormonal medications (i.e. birth control or hormonal replacement therapy), and having a major endocrine disorder (i.e. Cushing's disease, diabetes, or Addison's disease). In addition, all participants were asked to refrain from using nonprescription drugs and alcohol for 24 hours prior to the study, to eat breakfast prior to arriving at the laboratory, and to be well hydrated. Due to the possibility that women who are mothers might react differently to the *AI* challenge, we invited only childless, non-pregnant adult women. Due to the potential for blood or needle phobias to increase stress, volunteers with these fears were asked to refrain from participating.

## Overview of Procedures

During the recruitment email contact, enrolled women were instructed to complete a set of online questionnaires using Qualtrics. Upon arrival, research assistants reviewed the informed consent information and participants gave written informed consent. The study nurse inserted an indwelling intravenous catheter and collected repeated specimens across the protocols using a needleless stopcock mechanism kept patent with infusions of an anti-coagulant (heparin). Prior to testing all participants were exposed to a 15-minute closeness induction procedure with a confederate, intended to prime the "caregiving system." This was followed by a 15-minute stress period involving a reaction time test and modified Trier Social Stress test (Fredrickson, Mancuso, Branigan & Tugade, 2000). Volunteers who continued into the *AI* challenge component had a 10–15 minute recovery period after the end of the parent-study protocol described above and then underwent this *AI* challenge test by viewing the half-hour film segment. Blood specimens used for this add-on study were from three time points: (a) at the baseline time point of the parent study, which was 20-minutes into the post-catheter insertion recovery period; (b) one minute after the film's 'bonding scene', and (c) one minute after the film's 'abandonment scene'.

### Film Protocol and Segment Description

After the parent study, the participant remained in the room alone with the lights on to view the film on a 22 inch TV screen from a distance of seven feet. She was told only that she would be watching a segment of the movie *Artificial Intelligence*. A nurse entered the room at five minutes into the segment (one minute after the bonding scene), to draw a blood sample through the stopcock. The nurse then left the room while the participant continued to watch the film segment. The nurse returned to the room after 30 minutes to collect the final blood sample one minute after the abandonment scene.

The segment used for this protocol is that described by Wirth and Schultheiss (2006). It begins with a mother programming a robotic boy to recognize her as his mother. After initial programming, the robotic child calls her "mother." As the scene proceeds, the robotic boy becomes more attached to his mother. Five minutes into the scene, the robotic boy tells his mother that he loves her. This moment was identified as a time of bonding and marked the time point for the bonding scene blood specimen to be collected. As the story continues, the mother's real son comes home from the hospital and the robotic boy has a series of increasingly dangerous interactions with the human son and other children, resulting in a plan to dismantle him. The final scene portrays the woman bringing the robotic boy into the forest where she abandons him in hopes that he will survive. When the robotic boy realizes what is happening he pleads for his "mother" not to leave him. This moment was identified as a stressful moment portraying abandonment and marked the time point for the abandonment scene blood draw.

### Survey Measures

As explained above, the parent study was a social psychology experiment done on a convenience sample, so we were able to select by gender, but we were not able to select participants based on psychiatric status. We included measures in the survey that would permit us to characterize the volunteers on factors important to our theory that oxytocin response to an attachment system stress challenge would differ if the woman has posttraumatic spectrum psychiatric disorders. In a sample size of 15 college students, we did not expect many cases of such disorders to occur, so we used self-administered symptom reports that yield dimensional, interval-level variables for analysis. We assessed for history of childhood abuse and neglect and for symptoms of PTSD, depression, dissociation, somatization, and interpersonal sensitivity.

Twenty-eight relevant items from the Life Stressor Checklist were utilized to gather history of trauma exposure (Wolfe & Kimmerling, 1997). The Life Stressor Checklist was utilized because it includes nonlegal language, behaviorally specific questions, and a comprehensive list of traumatic events specific to women's life experiences, including traumatic reproductive and care giving experiences (Kilpatrick et al., 1994). For the purposes of this study, we created a total trauma exposure sum for descriptive purposes (range 0–28). We classified a woman as having a childhood maltreatment history if she reported physical neglect, emotional abuse, physical abuse, and sexual abuse involving contact only or penetration prior to age 16.

The PTSD-PCL civilian checklist (Weathers, Litz, Herman, Huska & Keane, 1993) is a 17-item self-report checklist used to identify the 17 symptoms of PTSD as outlined in the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 1994). The checklist prompts participants to select the level of distress ranging from *1=not at all* to *5=extremely* to describe each reported PTSD symptom over the prior 30 days. The sum of these items is then computed with a potential total ranging from 17–85. Posttraumatic stress disorder diagnosis was established with a cut-off score of 44 (Blanchard et al., 1996; Ruggiero, Del Ben, Scotti, & Rabalais, 2003). Initial psychometric testing by Weathers and colleagues (1993) demonstrated a test-retest reliability of 0.96 with validity established with a kappa of 0.64 in comparison to the Structured Clinical Interview (SCID). More recently, the PTSD-PCL was utilized with 392 college students and demonstrated a Cronbach's alpha reliability of 0.94 for the total scale, with a test-retest reliability of 0.92 for immediate re-testers, 0.88 for participants with one week intervals, and 0.68 for two-week interval re-testers (Ruggiero et al., 2003).

We measured depression symptoms with the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The BDI includes 21 items that are scored from *0 to 3* in terms of intensity (Beck, Steer, & Garbin, 1988). The BDI has demonstrated adequate reliability scores with means of .86 and .81 for psychiatric and nonpsychiatric patients respectively and acceptable validity testing compared with the Hamilton Psychiatric Rating Scale for Depression (Beck, Steer, & Garbin, 1988). The cut-off point indicating likely major depressive disorder is 30 (Beck, Steer, & Garbin, 1988).

Dissociation is an associated feature of PTSD and considered to be a component of complex PTSD or disorders of extreme stress not otherwise specified (DESNOS; Herman, 1992; 1997). Dissociative disorders also can occur in the absence of PTSD. The Dissociative Experiences Scale – Taxon (DES-T) is an eight-item measure that has been identified as a sensitive measure to identify pathological dissociation (Waller, Putnam, & Carlson, 1996). The DES-T is a self-report measure in which participants indicate the frequency of various dissociative experiences using percentages from *0 to 100* (Waller & Ross, 1997). The scores are then averaged to create a total score. Per Waller and Ross (1997), "In non-clinical samples, DES-T scores that are greater than 35 provide strong evidence that the individual belongs to the pathological dissociation taxon" (p. 506). In their non-clinical study the cut point of 35 was very conservative, with a sensitivity of .57, specificity of 1.0 and 100% positive predictive value for a dissociative disorder.

Somatization and interpersonal sensitivity are two additional associated features of PTSD or elements of complex PTSD or DESNOS. We used subscales of the Symptom Checklist 90 (SCL-90) to measure these symptoms (Derogatis, Lipman, & Covi, 1973). Although somatization and interpersonal sensitivity can reach diagnostic thresholds for somatoform and borderline personality disorder diagnoses, the SCL-90 subscales do not have validated cut- points. These subscales assess the presence of symptoms within the last seven days on a five point rating scale from *0=not at all* to *4=extremely*. The somatization and interpersonal subscales have previously demonstrated adequate reliability, including an internal consistency of .86 for both subscales and validity as established by adequate correlations

with the Minnesota Multiphasic Personality Index (MMPI; Derogatis, Rickels, & Rock, 1976).

### Hormonal Measures

Blood specimens were drawn with a 5mL luer-lock syringe from the stopcock mechanism after a 1–2mL waste to clear the heparin flush. Blood was immediately deposited into a 6mL vacutainer tube containing Ethylenediaminetetraacetic acid (EDTA) and 400KIU of the protease inhibitor Trasylol (Fisher BioReagents, United States) per 1 mL of blood. The vacuum seal was broken so that transfer could occur without hemolysis. Blood samples were kept ice-chilled for up to two and a half hours before being centrifuged at 4 degrees Celsius at 1,000 rpms for 15 minutes. All plasma samples were separated into aliquots and stored in a freezer at −80 degrees Celsius until assayed.

### Plasma Oxytocin Assay

Oxytocin Enzymimmunoassay was performed with a commercially available kit obtained from Assay Designs, Inc/Enzo Biomedical (Ann Arbor, MI) using duplicate samples from each aliquot. The plasma was diluted in assay buffer 1:2, to give results reliably within the linear portion of the standard curve. The intra-assay coefficient of variance was 9.1% and the inter-assay coefficient of variance was 6.0%. The values used in this analysis are the mean of the duplicates at each time point.

### Analysis Plan

Data were analyzed using IBM SPSS Statistics v.20.0. Preliminary analyses included descriptive statistics for demographics, trauma history, psychiatric symptom scores, and oxytocin values in relation to limits of detection and assessment of normality, homoscedasticity, and linearity of relationships among variables. Oxytocin concentration values are depicted in natural units (pg/mL) but statistical tests and regressions were conducted using log-transformed values.

For research question one, we tested hypotheses one through four with a repeated measures analysis of variance (RM-ANOVA) and its associated *post hoc* analyses. We explored the second research question that psychopathology would be associated with the pattern of oxytocin response using correlation coefficients (Pearson's $r$). Strong differences in correlations across different psychiatric measures led to a *post hoc* analysis of six selected cases to answer research question three. Due to the exploratory, pilot nature of this experiment, we prefer to risk a Type I error, so we accepted $p<.10$ as the level of statistical significance for interpretation. Given that we were able to specify directional hypotheses, we used one-tailed tests of significance.

## Results

### Participants

Participants (n=15) were female university students who ranged in age from 18–27 years old. All reported themselves to be within 14 days of the onset of their last menstrual period. They were predominantly white and characterized their family income as above average

(Table 1). All of the participants reported they were not of Hispanic ethnicity. Four participants reported a history of childhood abuse.

### Oxytocin Values in Response to the *AI* Challenge

Figure 1 displays the mean oxytocin values with standard error bars for the whole sample (n=15) in pg/mL, with natural log values depicted on a right-hand y axis. The first hypothesis that oxytocin level would change from the baseline to bonding scene was not supported (p=.393). The *post hoc* analysis for differences between the baseline and abandonment oxytocin values was significant (p=.010), supporting hypothesis number two. Hypothesis number three was supported with a significant *post hoc* analysis demonstrating a difference between oxytocin levels at the bonding and abandonment scenes (p=.041). Repeated-measures analysis of variance (RM-ANOVA, Table 2) was also conducted to assess hypothesis four, assessing the impact of time on oxytocin values across the three time periods (baseline, bonding, and abandonment). There was a significant main effect of time (i.e. effect of provocation), $F(2, 28)=3.61$, $p=.02$. This difference explains 21% of variance by partial eta squared and has an observed power of .62.

The second research question was about the extent to which posttraumatic spectrum psychopathology that can manifest subsequent to early relational trauma or childhood maltreatment and attachment problems might affect the oxytocin response. Our convenience sample size of 15 limited us to exploratory analyses with interval-level variables. In order to first assess the relationship of psychopathology symptoms to oxytocin levels (a diagnosis-centered exploration), we used a correlation matrix with the aggregate (Table 3). This correlation matrix demonstrated that there was a significant moderate relationship between symptoms of depression, dissociation, somatization, and interpersonal sensitivity and an increase in oxytocin level at the bonding scene time point. Only PTSD symptom count was significantly associated with a decrease in oxytocin level at the abandonment scene time point.

This pattern in the diagnosis-focused correlations led to a *post hoc* person-focused examination via six selected cases (Table 4). We selected six women representing the extremes within this small convenience sample by the following process. We sorted the data file in rank order by their PTSD symptom score on the PTSD Checklist, which can range from 17 (no symptoms) to 85 (all 17 symptoms rated at the highest level), and which has a validated cut-point of 44 corresponding to probable PTSD diagnosis (Blanchard et al., 1996; Ruggiero, Del Ben, Scotti, & Rabalais, 2003). Four of the 15 young women had a PTSD score >44. One of these women had a dissociation score of 54, well above the clinical cut-point of 35 (Waller & Ross, 1997). We separated these into one complex PTSD case and three PTSD-only cases. There were two women with no PTSD symptoms and no dissociation symptoms who we considered as healthy controls. We plotted the oxytocin curves of these six cases (Figure 2). The strongest pattern of response is within the woman distinguished by the high level of dissociation, whose oxytocin level increased by 155% at the bonding scene. This contrasts with the PTSD-only trio whose oxytocin levels all fell at the bonding scene, although to a less dramatic extent.

## Discussion

We offer the following very tentative conclusions in relation to this small exploratory pilot study. The results indicate that further research is warranted using the *AI* challenge protocol. Changes in oxytocin levels across the time points were noted at effect sizes that might be significant using larger sample sizes. A *post hoc* finding that warrants replication was that differences in the oxytocin response may serve to distinguish young women with posttraumatic stress disorder alone and those with dissociative psychopathology, including the dissociative subtype of PTSD (Stein et al., 2012). Overall, the *AI* challenge protocol appears to be a feasible and potentially useful provocation for studying oxytocin levels, particularly in relation to psychopathology of the attachment system.

### Test of Concept Conclusions

In relation to the first research question, hypotheses two through four were supported in this sample which demonstrated modest changes in oxytocin levels across the three time points. There was a decrease from the baseline to abandonment time point and a decrease from the bonding to abandonment time point. Although the hypothesized increase from baseline to bonding scene did not reach significance, hypothesis four was supported when the RM-ANOVA showed significant differences in oxytocin across the baseline, bonding, and abandonment time points.

In relation to the second research question, dissociation and somatization correlated most strongly with higher levels at the bonding scene, and PTSD correlated most strongly with lower levels at the abandonment scene. Although we did not expect to find cases of severe psychopathology in the form of PTSD or dissociation, there were participants with distinct psychiatric symptom patterns, allowing us to consider them as a preliminary indication of what a clinical sample might show. Consistent with what we found in another study of oxytocin, the woman with high dissociative symptoms had the strongest response to the provocation (Seng et al., 2013). Since dissociation psychopathology is strongly associated with early relational trauma (van der Kolk, 2005), and since oxytocin has been theorized to be dysregulated in the face of early relational trauma (Schore, 2003; Seng, 2010; Teicher et al., 2002), the correlation of dissociation symptom level and oxytocin level found here, as well as the pattern seen in this sentinel case, warrant further consideration. The overall lower level of the women with PTSD without dissociation also is consistent with findings from our previous research (Sent et al., 2013). This distinction makes some sense conceptually because PTSD is characterized as an anxiety disorder with hypervigilence (i.e., mistrust), both manifestations that would be more expected in the context of low levels of oxytocin. Whereas dissociation is a form of self-anesthesia in a context of threat and, in the context of maltreatment, may help the young child preserve trust in an untrustworthy parent in the interest of survival, manifestations that would be more expected in the context of high levels of oxytocin (Freyd, 1996). This distinction may also have a biological basis. The hypothalamic-pituitary-adrenal axis and oxytocin system are mutually regulating, so differences in cortisol levels may oppose oxytocin to different extents. Cortisol is sometimes high in PTSD, but has also been found to be low when the PTSD is chronic or from long-ago trauma exposures such as childhood maltreatment, or in women (Trickett, Noll, Susman,

Shenck, & Putnam, 2010; Meewisse, Reitsma, de Vries, Gersons, & Olff, 2007)). There is also evidence from one study that an enzyme that lyses oxytocin (prolyl endopeptidase) is more active in people with PTSD (Maes et al., 1999), suggesting that the breakdown of the hormone would be faster and amounts available in plasma lower. Current literature (Lanius et al, 2010; Seng, D'Andrea, & Ford, in press; Seng et al., 2013; Wolf et al., 2012; Stein et al., 2012) suggests that there may well be a dissociative subtype of PTSD. Thus the most interesting finding of this small study might be the hint that oxytocin may be a biomarker with utility for distinguishing these subtypes at the physiological level. Thus, we conclude that this protocol specifically, and oxytocin as a biomarker more generally, warrant further studies that characterize participants on a full range of posttraumatic psychopathology. To verify that the mechanism of the provocation is indeed a relational stressor affecting people differently according to their capacity or propensity to experience healthy attachment, measures of adult attachment should be included. As with any hormone, study of the hormone available in the peripheral circulation is only a rough proxy for its action on target tissues, and in this instance, as a neurotransmitter, so designs are needed that elucidate more elements of how the oxytocin system is functioning under provocation and across subtypes.

The effect sizes observed in the RM-ANOVA are modest but suggest that the protocol provokes a response that is discernable, on average, in a small group of unselected college women. Our *post hoc* exploration suggests that in a sample selected to contrast women with and without psychopathology, effect sizes might be larger. Thus, we conclude that further testing is needed to state that this protocol is a useful provocation for social psychology research on oxytocin in non-clinical samples. We recommend large enough healthy-control samples in future studies to determine utility and effect sizes within these normal samples compared with people in patient groups.

## Feasibility Conclusions

This protocol seemed well suited to our purpose because the science fiction story includes two "tear jerker" scenes, one in which the robot boy tells the human woman "I love you" for the first time, and one in which she reluctantly abandons him in the forest to prevent the need to dismantle him. There are other films we could have used, but they have disadvantages. For example, *Sophie's Choice* (Director: Alan Pakula, 1982) depicts abandonment of a child, but the context of the Nazi Holocaust might be an additional provocation. *The Kids are Alright* (Director: Lisa Cholodenko, 2010) depicts mothers dropping their daughter off at her dormitory at the start of her first year in college, but this context suggests a normal developmental milestone that might have as much positive valance as negative. Thus, *AI* as a science fiction film seemed to have the advantages of being free of contextual intensity and of including both a positive and negative manifestation of attachment.

The *AI* challenge protocol to assess plasma oxytocin reactivity is feasible. The film was acceptable to all participants. The data collection protocol worked well, with only one of 16 women (6%) losing venous access and no major departures from the established procedures. The specimen processing was hampered by the need to collect plasma in one building, holding it on ice for nearly three hours from the baseline draw in the parent study through

the last draw in the *AI* protocol, and transporting it on ice to another location for cold centrifuging and storage. The levels observed in this pilot, however, are consistent with those seen in another report where two hours elapsed (Feldman, Gordon, Schneiderman, Weisman, & Zagoory-Sharon, 2010), and in other studies as well (Gordon et al., 2008). As a stand-alone protocol, the *AI* challenge protocol, would take less than one hour. If the protocol took place in a clinical or academic facility with a cold centrifuge and freezer at hand, the theoretical risk of deterioration would be decreased.

### Strengths, Limitations, and Recommendations for Further Research

There are numerous limitations to this study, many of which are inherent to preliminary studies. First, the sample size was small and not selected for psychopathology. Observed power in the RM-ANOVA was .62, confirming that we were underpowered to draw solid conclusions. Our sample only included women in the follicular phase of the menstrual cycle and is therefore not generalizable to other populations including men, children, menopausal and pregnant or mothering women. Our specimens may have deteriorated due to the amount of time on ice. This limitation would have affected all 15 women in our sample equally, but it means that the values overall in this study may be low. That said, the lowest oxytocin levels observed are those measured at the end of the protocol, during the abandonment scene, where the delay from blood draw to freezer was the shortest and within the timeframe customary in other oxytocin studies. We did not measure attachment style or problems, so we do not have an indicator to use to verify the mechanism of this film segment as a stressor to the attachment system. Finally, this protocol was an add-on to a social psychology experiment that involved a closeness-induction and stress protocol that should have primed or activated the caregiving system. Our baseline levels represent a basal oxytocin level because it was drawn prior to these parent study manipulations. However, the manipulations occurring between baseline and the *AI* challenge protocol may have affected the response to the film. We do not know if the priming and stressing in the parent protocol would have the effect of making pilot participants more reactive or less reactive, possibly due to fatigue. For example, this priming may have activated the attachment system prior to our provocation which could have potentially blunted the effects of the *AI* bonding scene. Therefore, testing the *AI* challenge as a stand-alone protocol is an essential next step.

There were strengths to this study as well. The team is experienced at complex social research protocols involving manipulations and blood specimen collection. The Carter laboratory is very experienced at oxytocin assaying and analysis of the raw data. Using an unselected convenience sample of female college students is a conservative first approach since it would usually be considered a homogenous sample, and the amount of variance observed would be considered a likely minimum.

## Conclusions

This exploratory pilot study indicated that the attachment system stress protocol we were testing did appear to affect oxytocin levels as evidenced by the RM-ANOVA showing significant differences in oxytocin across the baseline, bonding, and abandonment time points. Additionally, correlations with oxytocin indicated that posttraumatic spectrum

psychopathology influenced oxytocin levels. *Post hoc* analyses also revealed differences in oxytocin response related specifically to dissociation in one sentinel case. Thus, this study demonstrated that the oxytocin response garnered using the *AI* challenge has the potential to become a way to characterize psychopathology secondary to attachment trauma. In order to pursue research on oxytocin in relation to psychiatric diagnosis and subtyping, treatment development, and outcomes research, additional validation studies are needed to investigate the relationship between psychopathology and oxytocin.

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## References

Ainsworth MDS. Object relations, dependency, and attachment: A theoretical review of the infant-mother relationship. Child Development. 1969; 40(4):969–1025. [PubMed: 5360395]

Ainsworth MDS. Patterns of infant-mother attachments: Antecedents and effects on development. The New York Academy of Medicine. 1985; 61(9):771–791.

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4. Washington, DC: Author; 1994.

Bartz JA, Hollander E. The neuroscience of affiliation: Forging links between basic and clinical research on neuropeptides and social behavior. Hormones and Behavior. 2006; 50:518–528. [PubMed: 16884725]

Beck AT, Steer RA, Garbin MG. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical Psychology Review. 1988; 8:77–100.

Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. Archives of General Psychiatry. 1961; 4:561–571. [PubMed: 13688369]

Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD checklist (PCL). Behavior Research Therapy. 1996; 34(8):669–673.

Carter CS. Neuroendocrine perspectives on social attachment and love. Psychoneuroendocrinology. 1998; 23(8):779–818. [PubMed: 9924738]

Carter CS, Boone EM, Pournajafi-Nazarloo H, Bales KL. Consequences of early experiences and exposure to oxytocin and vasopressin are sexually dimporphic. Developmental Neuroscience. 2009; 31(4):332–341.10.1159/000216544 [PubMed: 19546570]

Carter, CS.; Porgess, SW. Social bonding and attachment. In: Koob, G.; Le Moal, M.; Thompson, R., editors. Encyclopedia of behavioral Neuroscience. New York, NY: Elsevier Ltd; 2010. p. 257-262.

Carter CS, Pournajafi-Nazarloo H, Kramer KM, Ziegler TE, White-Traut R, Bello D, Schwertz D. Oxytocin: Behavioral associations and potential as a salivary biomarker. Annals of New York Academy of Sciences. 2007; 1098:312–322.

Cyranowski JM, Hofkins TL, Frank E, Seltman H, Cai HM, Amico JA. Evidence of dysregulated peripheral oxytocin regulation among depressed women. Psychosomatic Medicine. 2008; 70:967–975. [PubMed: 19005082]

Derogatis LR, Lipman RS, Covi L. The SCL-90: An outpatient psychiatric rating scale. Psychopharmacology Bulletin. 1973; 9:13–28. [PubMed: 4682398]

Derogatis LR, Rickels K, Rock AF. The SCL-90 and the MMPI: A step in the validation of a new self-report scale. The British Journal of Psychiatry. 1976; 128:280–289.10.1192/bjp.128.3.280 [PubMed: 1252693]

Diamond LM. Contributions of psychophysiology to research on adult attachment: Review and recommendations. Personality and Social Psychology Review. 2001; 5(4):276–295.10.1207/S15327957PSPR0504_1

Drago F, Pedersen CA, Caldwell JD, Prange AJ. Oxytocin potently enhances novelty-induced grooming behavior in the rat. Brain Research. 1986; 368(2):287–295. [PubMed: 3697728]

Feldman R, Gordon I, Influs M, Gutbir T, Ebstein RP. Parental oxytocin and early caregiving jointly shape children's oxytocin responses and social reciprocity. Neuropsychopharmacology. 2013 Advance online publication. 10.1038/npp.2013.22

Feldman R, Gordon I, Schneiderman I, Weisman O, Zagoory-Sharon O. Natural variations in maternal and paternal care are associated with systematic changes in oxytocin following parent-infant contact. Psychoneuroendocrinology. 2010; 35:1133–1141.10.1016/j.psyneuen.2010.01.013 [PubMed: 20153585]

Ferguson JN, Young LJ, Hearn EF, Matzuk MM, Insel TR, Winslow JT. Social amnesia in mice lacking the oxytocin gene. Nature Genetics. 2000; 25:284–288. [PubMed: 10888874]

Fredrickson BL, Mancuso RA, Branigan C, Tugade MM. The undoing effect of positive emotions. Motivation and Emotion. 2000; 24:237–258. [PubMed: 21731120]

Freyd, JJ. Betrayal trauma: The logic of forgetting childhood abuse. Cambridge, MA: Harvard University Press; 1996.

Gordon I, Zagoory-Sharon O, Schneiderman I, Leckman JF, Weller A, Feldman R. Oxytocin and cortisol in romantically unattached adults: Associations with bonding and psychological distress. Psychophysiology. 2008; 45:349–352.10.1111/j.1469-8986.2008.00649.x [PubMed: 18266803]

Gouin J, Carter CS, Pournajafi-Nazarloo H, Glaser R, Malarkey WB, Loving TJ, Kiecolt-Glaser JK. Marital behavior, oxytocin, vasopressin, and wound healing. Psychoneuroendocrinology. 2010; 35(7):1082–1090.10.1016/j.psyneuen.2010.01.009 [PubMed: 20144509]

Heinrichs M, von Dawans B, Domes G. Oxytocin, vasopressin, and human social behavior. Frontiers in Neuroendocrinology. 2009; 30:548–557.10.1016/j.yfrne.2009.05.005 [PubMed: 19505497]

Herman JL. Complex PTSD: A syndrome in survivors of prolonged and repeated trauma. Journal of Traumatic Stress. 1992; 5(3):377–391.

Herman, JL. Trauma and recovery. New York: Basic Books; 1997.

Insel TR, Hulihan TJ. A gender-specific mechanism for pair bonding: Oxytocin and partner preference formation in monogamous voles. Behavioral Neuroscience. 1995; 109(4):782–789. [PubMed: 7576222]

Keverne EB, Nevison CM, Martel FL. Early learning and the social bond. Annals of the New York Academy of Science. 1997; 807:329–339.

Kilpatrick, DG.; Resnick, HS.; Freedy, JR.; Pelcovitz, D.; Resick, PA.; Roth, S.; van der Kolk, B. DSM-IV Sourcebook. Washington, DC: American Psychiatric Press; 1994. The posttraumatic stress disorder field trial: Emphasis on criterion A and overall PTSD diagnosis.

Lanius RA, Vermetten E, Loewenstein RJ, Brand B, Schmahl C, Bremner D, Spiegel D. Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. American Journal of Psychiatry. 2010; 167(6):640–647.10.1176/appi.ajp.2009.09081168 [PubMed: 20360318]

Maes M, Lin AH, Bonaccorso S, Goossens F, Van Gastel A, Pioli R, Scharpé SJ. Journal of Affective Disorders. 1999; 53(1):27–34. [PubMed: 10363664]

McCarthy MM, Kow LM, Pfaff DW. Speculations concerning the physiological significance of central oxytocin in maternal behavior. Annals of the New York Academy of Sciences. 1992; 652:70–82. [PubMed: 1626859]

Meaney MJ. Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations. Annual Review of Neuroscience. 2001; 24:1161–1192.

Meewisse ML, Reitsma JB, de Vries GJ, Gersons BP, Olff M. Cortisol and post-traumatic stress disorder in adults: Systematic review and meta-analysis. British Journal of Psychiatry. 2007; 191:387–392. [PubMed: 17978317]

Panksepp J, Nelson E, Bekkedal M. Brain systems for the mediation of social separation-distress and social-reward evolutionary antecedents and neuropeptide intermediaries. Annals of the New York

Academy of Sciences. 2006; 807(1):78–100.10.1111/j.1749-6632.1997.tb51914.x [PubMed: 9071345]

Pedersen CA. Oxytocin control of maternal behavior: Regulation by sex steroids and offspring stimuli. Annals of the New York Academy of Sciences. 1997; 807(1):126–145. [PubMed: 9071347]

Pedersen CA, Prange AJ. Induction of maternal behavior in virgin rats after intracerebroventricular administration of oxytocin. Proceedings of the National Academy of Sciences. 1979; 76(12):6661–6665.

Pierrehumbert B, Torrisi R, Ansermet F, Borghini A, Halfon O. Adult attachment representations predict cortisol and oxytocin responses to stress. Attachment & Human Development. 2012; 14(5): 453–476. [PubMed: 22856618]

Pierrehumbert B, Torrisi R, Laufer D, Halfon O, Ansermet F, Beck Popovic M. Oxytocin response to an experimental psychosocial challenge in adults exposed to traumatic experiences during childhood or adolescence. Neuroscience. 2010; 166(1):168–177. [PubMed: 20018229]

Porges, SW. The Polyvagal Theory. New York: W.W. Norton & Co., Inc.; 2011.

Ruggiero KJ, Del Ben K, Scotti JR, Rabalais AE. Psychometric properties of the PTSD checklist-civilian version. Journal of Traumatic Stress. 2003; 16(5):495–502. [PubMed: 14584634]

Schore, AN. Affect dysregulation and disorders of the self. New York: WW Norton & Company Inc.; 2003.

Skrundz M, Bolten M, Nast I, Hellhammer DH, Meinlschmidt G. Plasma oxytocin concentration during pregnancy is associated with development of postpartum depression. Neuropsychopharmacology. 2011; 36(9):1886–1893.10.1038/npp.2011.74 [PubMed: 21562482]

Seng J. Is posttraumatic oxytocin dysregulation a link among posttraumatic self disorders, posttraumatic stress disorder, and pelvic visceral dysregulation conditions in women? Journal of Trauma and Dissociation. 2010; 11:387–406. [PubMed: 20938865]

Seng JS, D'Andrea W, Ford JD. Trauma history and empirically derived psychiatric syndromes in a community sample of women in prenatal care. Psychological Trauma: Research Theory, Practice, and Policy. (in press).

Seng JS, Miller JM, Sperlich M, van de Ven CJM, Brown SB, Carter SC, Liberzon I. Exploring dissociation and oxytocin as pathways between trauma exposure and trauma-related hyperemesis gravidarum: A test-of-concept pilot. Journal of Trauma & Dissociation. 2013; 14(1):40–55.10.1080/15299732.2012.694594 [PubMed: 23282046]

Stein DJ, Koenen KC, Friedman MJ, Hill E, McLaughlin KA, Petukhova M, Kessler RC. Dissociation in posttraumatic stress disorder: Evidence from the world mental health surveys. Biological Psychiatry. 2012 Advance online publication. 10.1016/j.biopsych.2012.08.022

Taylor SE. Tend and befriend: Biobehavioral bases of affiliation under stress. Current Directions in Psychological Science. 2006; 15(6):273–277.

Teicher MH, Andersen SL, Polcari A, Anderson CM, Navalta CP. Developmental neurobiology of childhood stress and trauma. Psychiatric Clinics of North America. 2002; 25:397–426. [PubMed: 12136507]

Trickett PK, Noll JG, Susman EJ, Shenk CE, Putnam FW. Attenuation of cortisol across development for victims of sexual abuse. Development and Psychopathology. 2010; 22(1):165–175. [PubMed: 20102654]

Uvans-Moberg, K. The oxytocin factor: Tapping the hormone of calm, love, and healing. Cambridge, MA: Da Capo Press; 2003.

van der Kolk BA. Developmental trauma disorder. Psychiatric Annals. 2005; 35(5):401–408.

Waller NG, Putnam FW, Carlson EB. Dissociation and dissociative types: A taxometric analysis of dissociative experiences. Psychological Methods. 1996; 1(3):300–321.

Waller NG, Ross CA. The prevalence and biometric structure of pathological dissociation in the general population: Taxometric and behavior genetic findings. Journal of Abnormal Psychology. 1997; 106(4):499–510. [PubMed: 9358680]

Weathers, FW.; Litz, BT.; Herman, DS.; Huska, JA.; Keane, TM. The PTSD checklist: reliability, validity, & diagnostic utility; Paper presented at the Annual Meeting of the International Society for Traumatic Stress Studies; San Antonio, TX. 1993.

Williams JR, Insel TR, Harbaugh CR, Carter CS. Oxytocin administered centrally facilitates formation of a partner preference in female prairie voles (Microtus ochrogaster). Journal of Neuroendocrinology. 1994; 6:247–250. [PubMed: 7920590]

Wirth MM, Schultheiss OC. Effects of affiliation arousal (hope of closeness) and affiliation stress (fear of rejection) on progesterone and cortisol. Hormones and Behavior. 2006; 50:786–795. [PubMed: 17010974]

Wolf EJ, Miller MW, Reardon AF, Ryabchenko KA, Castillo D, Freund R. A latent class analysis of dissociation and PTSD: Evidence for a dissociative subtype. Archives of General Psychiatry. 2012; 69(7):698–705.10.1001/archgenpsychiatry.2011.1574 [PubMed: 22752235]

Wolfe, J.; Kimerling, R. Gender issues in the assessment of posttraumatic stress disorder. In: Wilson, JP.; Keane, TM., editors. Assessing psychological trauma and PTSD. New York, NY: Guilford Press; 1997. p. 192-238.

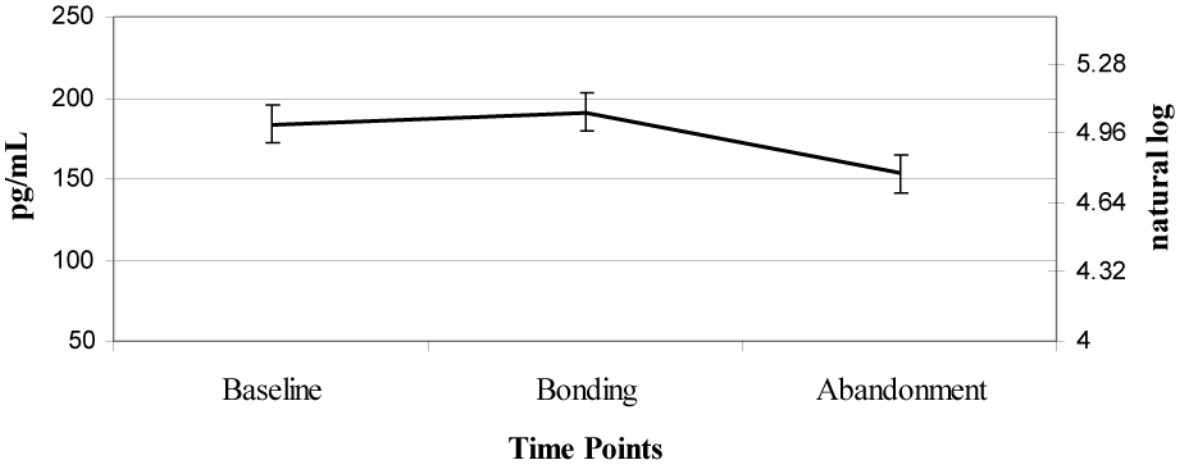


**Figure 1.**
Mean Oxytocin Values Across Three Protocol Time Points

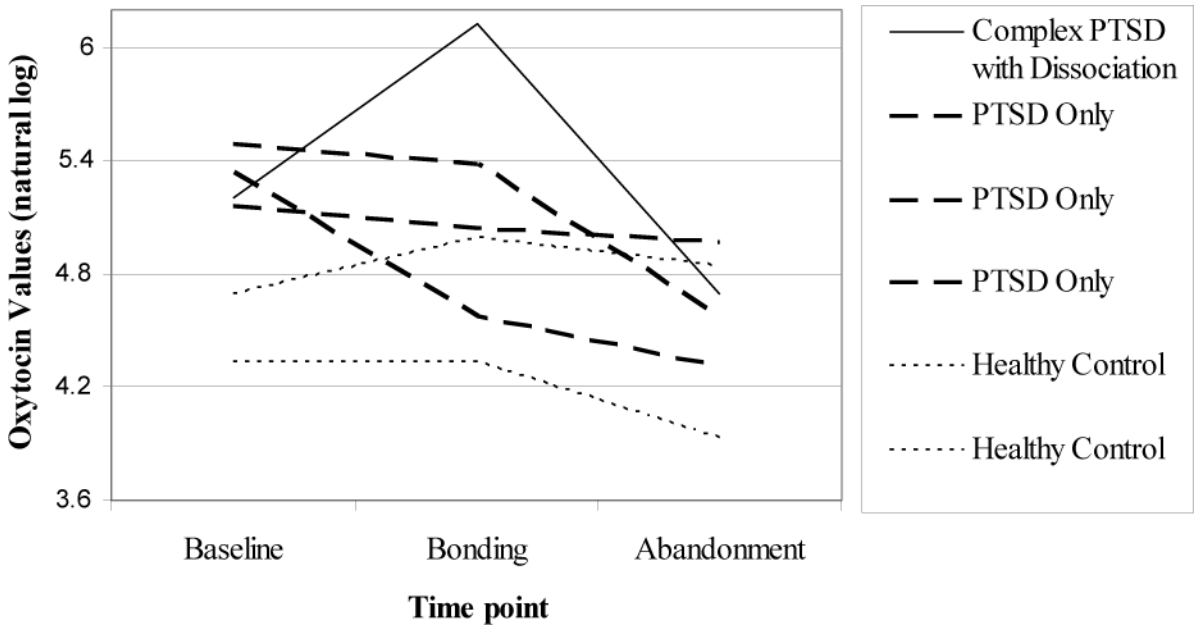


**Figure 2.**
Oxytocin Values and Psychopathology for Six Selected Cases

**Table 1**

Characteristics of the Study Sample

| **Demographics** | |
|---|---|
| **Mean Age (SD)** | 21.7 (2.6) |
| **Race** | **% (n)** |
| **Caucasian** | 46.7 (7) |
| **African America** | 13.3 (2) |
| **Asian or Pacific Islander** | 40.0 (6) |
| **Income** | **% (n)** |
| **Below average** | 13.3 (2) |
| **Average** | 26.7 (4) |
| **Above average** | 60.0 (9) |
| **Trauma History** | |
| **Mean Number of Trauma Exposures (SD)** | 2.9 (2.3) |
| **History of Child Abuse** | **% (n)** |
| **Positive for physical, sexual, or emotional** | 26.7 (4) |
| **Psychiatric Symptom Scores** | **Mean (Standard Deviation)** |
| **Posttraumatic Stress Disorder Symptoms** | 32.1 (13.4) |
| **Dissociation Symptoms** | 6.7 (13.2) |
| **Interpersonal Sensitivity Symptoms** | 19.7 (6.0) |
| **Somatization Symptoms** | 18.4 (6.9) |
| **Depression Symptoms** | 30.8 (11.6) |
| **Oxytocin Levels (pg/mL)** | **Mean (Standard Deviation)** |
| **Baseline** | 183.6 (77.5) |

## Table 2

Oxytocin Changes Across Protocol for the Sample (using the natural log of oxytocin level)

| Time Point | Whole Sample (n=15) | | |
|---|---|---|---|
| | **F(df=2,28)** | **Partial eta squared** | **Observed Power** |
| **RM-ANOVA** | 3.61, p=.02 | .21 | .62 |
| | **Mean Difference** * | **Standard Error** * | **p** ** |
| **Baseline to Bonding** | .032 | .113 | .393 |
| **Baseline to Abandonment** | −.309 | .116 | .010 |
| **Bonding to Abandonment** | −.278 | .148 | .041 |

* Based on estimated marginal means

** Significance determined using p<.10, one-tailed

## Table 3

Correlations of Psychopathology with Oxytocin Level across the Protocol

| | Baseline** | Bonding Scene** | Abandonment Scene** |
|---|---|---|---|
| **Child Abuse Total*** | $r = .034$, $p = .452$ | $r = -.109$, $p = .349$ | $r = -.204$, $p = .233$ |
| **PTSD Score** | $r = -.025$, $p = .464$ | $r = .190$, $p = .249$ | $r = -.352$, $p = .099$ |
| **Depression Score** | $r = -.126$, $p = .328$ | $r = .449$, $p = .047$ | $r = -.113$, $p = .345$ |
| **Dissociation Score** | $r = -.021$, $p = .471$ | $r = .545$, $p = .018$ | $r = -.045$, $p = .436$ |
| **Somatization Score** | $r = -.042$, $p = .441$ | $r = .593$, $p = .010$ | $r = -.189$, $p = .250$ |
| **Interpersonal Sensitivity Score** | $r = .131$, $p = .321$ | $r = .354$, $p = .098$ | $r = -.130$, $p = .322$ |

* Child abuse total is the sum of types of abuse: physical neglect, emotional, physical, and contact and penetration sexual abuse

** All p-values are one-tailed

**Table 4**

Depiction of Mental Health, Trauma History, and Oxytocin Response across Six Influential participants.

| ID | 17 | 37 | 75 | 113 | 28 | 30 |
|---|---|---|---|---|---|---|
| Trauma history | No trauma reported | Index trauma was prior traumatic miscarriage or abortion. Also reported accident, emotional abuse, witnessing parent violence, physical abuse as child and adult, sexual harassment, severe money problems, death of a loved one | Index trauma was emotional abuse. Also reported family member jailed, witnessing parent violence | No 'worst' trauma. Reported sudden death of a loved one, death of a loved one | No trauma reported | No 'worst' trauma. Reported sudden death of a loved one |
| PTSD (17–85) | 54 | 50 | 50 | 48 | 17 | 17 |
| Dissociation (0–100) | 50 | 0 | 20 | 6 | 0 | 0 |
| Interpersonal sensitivity (0–40) | 30 | 28 | 18 | 22 | 10 | 17 |
| Somatization (0–52) | 41 | 18 | 14 | 17 | 16 | 14 |
| Depression (0–63) | 63 | 35 | 38 | 24 | 21 | 26 |
| Mental health | PTSD, dissociation, depression | PTSD only | PTSD only | PTSD only | Healthy | Healthy |
| Direction | ↑ | ↓ | ↓ | ↓ | ↑ | No change |
| Change (pg/mL) | 279 | −24 | −20 | −112 | +38 | 0 |
| Percent change from baseline | +155% | −10% | −11% | −54% | +35% | 0% |