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Self-Reported Spirituality Correlates With Endogenous Oxytocin

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Spirituality involves a feeling of profound personal connection to a sacred reality (e.g., God), and is often characterized by experiences of comfort and peace. The neuropeptide oxytocin appears to be a plausible biological mediator of such spiritual experiences, as oxytocin is closely linked with social affiliation, intimacy, and stress-attenuation. Here, we investigated the relationship between endogenously generated oxytocin and self-reported trait spirituality among a group of devout North American Christians. In line with emerging perspectives linking oxytocin with social affiliation, but not with positive asocial feelings in general, trait spirituality predicted higher levels of salivary oxytocin, and this association was not explained by covarying positive mood, optimism, romantic relationship status, or sex. The results are discussed as they motivate future directions in research on oxytocin and spirituality.

Keywords: oxytocin, religion, social cognition, spirituality

"Spirituality" stubbornly resists definition, but may be provisionally sketched as a feeling of personal connection to a sacred reality such as God or a Higher Power (Hill et al., 2000). Indeed, studies employing diverse psychological and neuroimaging methods have demonstrated that God is conceptualized as a kind of person, represented using the mental systems supporting everyday social interactions (Schjødt, Stødkilde-Jørgensen, Geertz, & Roepstorff, 2009). In addition to coopting social–cognitive processes, the sense of spiritual affinity with a sacred reality is often characterized by blissful experiences of peace and trust in the divine, and prayer has been linked to brain areas implicated in social reward in Christians (e.g., dorsal striatum; Schjødt, Stødkilde-Jørgensen, Geertz, & Roepstorff, 2008). In sum, spirituality appears to involve a rewarding sense of affiliation with a benevolent agent.

Oxytocin, an evolutionarily ancient neuropeptide hormone, downregulates stress and enhances social bonding in mammals (Meyer-Lindenberg et al., 2011), and hence may importantly mediate experiences of spirituality in humans. Oxytocin is produced in the hypothalamus and projected throughout a network of brain regions related to social cognition, motivation, and attachment (Hahn-Holbrook, Holbrook, & Haselton, 2011). Higher levels of plasma oxytocin in pregnancy predict enhanced mother–infant bonding postpartum (Feldman, Weller, Zagoory-Sharon, & Levine, 2007). Beyond parenting, oxytocin is linked with social warmth, intimacy, and trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005), eye contact (Guastella, Mitchell, & Dadds, 2008), sensitivity to social support (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003), and emotional empathy (Hurlemann et al., 2010). Relative to placebo, experimentally administering oxytocin improves social recognition in people with autism spectrum disorders (Guastella et al., 2010) and enhances encoding of positive social memories (Guastella, Mitchell, & Mathews, 2008). In sum, converging lines of evidence suggest that oxytocin makes up part of the neurochemical foundation of social cognition and stress-regulation. To the extent that relationships with God draw on the same cognitive architecture, oxytocin may well modulate experiences of the sacred (Grigorenko, 2012).

In line with this reasoning, a recent study found evidence of a relationship between oxytocin and spirituality in an HIV-positive sample (Kelsch et al., 2013). Plasma oxytocin levels in 38 chronically diseased HIV patients and 41 highly spiritual patients living with HIV were compared with self-reported measures of spirituality, religiosity, and religious behaviors. The authors found that higher levels of oxytocin were correlated with how spiritual, but not how religious, participants reported themselves to be. Furthermore, oxytocin levels were twice as high in participants who had experienced a spiritual transformation than in those who had not. Although these results are supportive of the hypothesis that oxytocin is biologically related to experiences of spirituality, the design employed by Kelsch and colleagues was subject to several limitations. For example, the majority of Kelsch et al.'s (2013) sample was taking various antiretroviral medications which may have unforeseen effects on oxytocin levels. In addition, experiences of spirituality among the terminally ill may not be representative of those of healthy individuals, for whom the prospect of an afterlife may harbor less immediate motivational force (McClain-Jacobson et al., 2004; Holbrook, Sousa, & Hahn-Holbrook, 2011; Jonas et al., 2014).

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Here, we test the link between spirituality and oxytocin in healthy members of a religious community likely to experience intense feelings of spirituality. To rule out the possibility that the postulated relationship between oxytocin and spirituality owes to a third variable that could covary with both spirituality and oxytocin, we also measured mood, optimism (see Saphire-Bernstein, Way, Kim, Sherman, & Taylor, 2011), relationship status, age, sex, and church attendance. Oxytocin was unobtrusively measured via saliva, as salivary oxytocin has been confirmed to correlate with plasma oxytocin (r = .59; Grewen, Davenport, & Light, 2010), and to increase with intranasal oxytocin administration (Weisman, Zagoory-Sharon, & Feldman, 2012). Participation was restricted to individuals who were not experiencing physical or mental health problems. To reduce noise, participation was also limited to nonparents, as oxytocin is associated with parenting (Gordon, Zagoory-Sharon, Leckman, & Feldman, 2010; Hahn-Holbrook et al., 2011).

Method

Thirty-four adult participants (M_{age} = 21.82 years, SD = 2.44) were recruited from Brigham Young University to take part in a study advertised as concerning 'Hormones and Cognition,' in exchange for course credit. The sample was 55.9% female, 94.1% White, and 29.4% married.

Participants completed an online survey before providing saliva. In the online survey, participants self-reported their degree of spirituality by answering *To what extent do you consider yourself a spiritual person?* on a 6-point scale (1 = *Not at all*; 6 = *Extremely*). To account for the possible link between social participation in church activities, spirituality, and oxytocin, participants were also asked to report their habitual church attendance, *How frequently do you attend church activities?* on a 6-point scale (1 = *Never*; 2 = *Rarely*; 3 = *A few times per year*; 4 = *About once per month*; 5 = *Weekly*; 6 = *Several times per week*). Trait optimism was assessed using the optimism subscale of the Life Orientation Test—Revised (α = .76; Scheier, Carver, & Bridges, 1994). Trait affect was assessed using the Positive and Negative Affect Scales (Watson & Clark, 1991; Positive: α = .82; Negative: α = .90). Participants also reported their current relationship status (1 = *single/not dating*; 2 = *in a relationship*; 3 = *married*).

We followed the procedures used for saliva collection and measurement employed in several previous studies (Grewen et al., 2010; Holt-Lunstad, Birmingham, & Light, 2008; Weisman et al., 2012). Salivary oxytocin samples were obtained using unstimulated passive drool collected into 4-ml plastic tubes. Saliva was collected after a 10-min baseline period during which participants were asked to simply sit and relax, in an attempt to reduce noise introduced by oxytocin-inducing stimuli encountered before the laboratory session (e.g., positive social interactions). Samples were immediately placed on ice, then transported to a freezer where they were stored at −20 °C until shipped on dry ice to the University of North Carolina (where they were stored at −80 °C) for assay using a commercially available enzyme immunoassay kit (Oxytocin EIA kit, Assay Designs, Ann Arbor, Michigan). Our salivary assay method included the extraction step recommended by the kit's manufacturer.[1] Three oxytocin samples were under the lower detection limit of the assay (2.0 pg/ml), and therefore set at 2.0 pg/ml before the analyses.

Results

The sample self-reported high levels of spirituality (M = 5.38, SD = .55), with a mean oxytocin level of 6.07 pg/ml (SD = 2.56).[2] Preliminary correlations were conducted to assess whether church attendance, optimism, positive or negative affect, age, or relationship status predicted oxytocin levels or spirituality. Church attendance was significantly positively correlated with self-reported spirituality, but not to oxytocin levels. In nonsignificant trends, spirituality was also positively associated with positive affect and with being in a more committed relationship (see Table 1). Spirituality was also marginally greater in women (M = 5.53, SD = .51) than in men (M = 5.20, SD = .56), $F(1, 32) = 3.13$, $p < .09$; there was no sex difference in oxytocin levels, $p > .8$. Neither spirituality nor oxytocin were predicted by optimism, negative affect, or age ($ps > .3$).

Next, self-reported spirituality was linearly regressed on oxytocin scores, revealing a positive association (β = .43, p = .01). The robustness of this association was then tested by controlling for the

[1] Extraction of the oxytocin peptide was performed together in the same batch, as described in the manual accompanying the kit. The first step was to equilibrate a strata-X 33 μm polymeric reversed phase SPE sorbent in a 96-well plate containing 60 mg of sorbent per well (Phenomenex, Torrance, CA) by adding 1 ml of MeOH followed by 1 ml of water. The second step was to acidify 0.8 ml of saliva with 0.4 ml of 1.5% trifluoroacetic acid (TFA) and centrifuge at 6000*g* for 20 minutes at 4°C. Third, this supernatant was loaded onto the pretreated strata-X plate, and the wells were slowly washed with 1.5 ml of 0.1% TFA. Fourth, the peptide was eluted with 1 ml of 80% acetonitrile; then, the eluant was collected in a polystyrene tube and evaporated to dryness under a N2 stream. Finally, the residue was reconstituted in 250 μL of assay buffer. The result of this extraction was to concentrate the sample 3.2 times and to reduce matrix interference. Extraction efficiency was determined by spiking samples with a known amount of hormone and extracting with the other samples. Next, oxytocin levels in the extracted saliva were measured in the same batch, using assay kits and protocols obtained from Assay Designs, Inc. The endogenous oxytocin hormone competes with oxytocin linked to alkaline phosphatase for the oxytocin antibody binding sites. After overnight incubation at 4°C, the excess reagents were washed away and the bound oxytocin phosphatase was incubated with the substrate. After an hour, this enzyme reaction (which generates a yellow color) was stopped. The optical density was read on a Sunrise plate reader (Tecan, Research Triangle Park, NC) at 405 nm. The kit states that the sensitivity limit of the assay with the current oxytocin antibody (without correcting for the concentration produced by the extraction process) is more than twice as high as with the older antibody at 11.6 pg/ml. With correction for the extraction process as described above, the lower limit of sensitivity was reduced to 2.0 pg/ml (Holt-Lunstad, Birmingham, & Light, 2008). The intra- and interassay variation for this assay is 4.8% and 8%, respectively. Assay Designs reports cross-reactivity for similar neuropeptides found in mammalian sera at < 0.001.

[2] Of the 34 participants in this highly religious sample, only one provided a score of less than 5 on the 6-point spirituality rating. This individual, who rated themselves a "4," also had the lowest possible oxytocin score. Although this is consistent with expectations, we were concerned about an outlier effect and, accordingly, ran several checks. First, we removed the participant and reran both the simple correlation and the simultaneous regression model reported in Table 2. The simple correlation between oxytocin and spirituality remained significant, $r(33) = .36$, p = .04; the association also remained significant in the regression model (β = .43, $p < .03$). Next, we winsorized the oxytocin scores to between the 5th and 95th percentiles. This did not change the result; oxytocin remained positively correlated with spirituality, $r(34) = .42$, $p < .02$, and the two variables remained significantly associated in the regression model (β = .48, $p < .02$).

Table 1
Correlations Between Demographic and Affective Covariates, Oxytocin, and Spirituality

Demographic	Coeff	Oxytocin	Spirituality
Age	*r*	.01	.03
Relationship status	*rs*	.02	.29†
Positive affect	*r*	.08	.28†
Negative affect	*r*	.05	−.11
Optimism	*r*	−.15	.16
Church attendance	*rs*	.11	.38*

Note. $n = 34$. *r* = Pearson's correlation; *rs* = Spearman's correlation. † $p \leq .10$. * $p < .05$.

variables found to be associated with spirituality in this sample: church attendance, positive affect, sex, and relationship status. In a simultaneous linear regression model, oxytocin significantly predicted spirituality ($\beta = .53$, $p = .01$) with no other such association observed for any of the covariates (see Table 2).

Discussion

Self-reported spirituality was positively associated with endogenous oxytocin, a relationship that was not explained by covarying church attendance, positive mood, sex, or relationship status. The specificity of the connection to spirituality, but not positive mood or optimism, accords with the widely held conceptualization of oxytocin as regulating social cognition in particular, rather than hedonic feelings in general (Bartz, Zaki, Bolger, & Ochsner, 2011). Thus, the present pattern of results is consistent with the idea that the supernatural agents with whom one might feel spiritually connected are represented using mechanisms employed in everyday social cognition (Boyer, 2001). This finding may illuminate biological mechanisms by which spirituality predicts stress-related health outcomes (Powell, Shahabi, & Thoresen, 2003; Holt-Lunstad, Steffen, Sandberg, & Jensen, 2011), as oxytocin evoked by social affiliation activates the parasympathetic nervous system, attenuating sympathetic activity (Gutkowska & Jankowski, 2012).

Our results replicate those found previously by Kelsch and colleagues (2013), who also observed a positive correlation between oxytocin and self-reported spirituality in a sample of HIV-positive individuals. The authors speculate that spirituality may function to reduce fear and enhance feelings of bonding, which may benefit persons with HIV by alleviating negative subjective feelings and, at the biological level of description, slowing the progression of the disease by reducing inflammation and boosting immune function. Thus, both spirituality and the activation of oxytocin systems related to marshalling health responses may be particularly relevant to persons confronting life-threatening illness. Importantly, however, the results of the present study demonstrate that the positive association between oxytocin and spirituality generalizes to a nonclinical sample of healthy undergraduates.

Spirituality and oxytocin are widely identified with prosociality and well-being; importantly, however, both spirituality and oxytocin may engender negative social sequelae under certain circumstances. For instance, intense spiritual commitment may facilitate acts of aggression committed on behalf of in-groups (Atran & Ginges, 2012; Kruglanski, Chen, Dechesne, Fishman, & Orehek, 2009). The dual role of spirituality as predictive of love and empathy, on the one hand, and virulent defense of sacred values, on the other, appears intriguingly paralleled by oxytocin. Oxytocin administration motivates parochial cooperation and empathy with in-group members over out-group members, increases defensive aggression on behalf of in-groups (De Dreu, 2012), and has been implicated in heightened maternal aggression in defense of children (Hahn-Holbrook, Holt-Lunstad, Holbrook, Coyne, & Lawson, 2011). Integrating these lines of inquiry, future research might explore the contribution of oxytocinergic systems to aggressive acts that are perceived by the perpetrators as spiritually righteous.

At the level of method, the present results, obtained via saliva assay, successfully replicate results derived from plasma assay (Kelsch et al., 2013). This replication is especially pertinent in light of recent concerns that have been raised regarding oxytocin assay (Szeto et al., 2011; McCullough, Churchland, & Mendez, 2013). For example, Horvat-Gordon et al. (2005) failed to find detectable levels of oxytocin in saliva—but these authors utilized a different extraction procedure and a different assay than those employed in the present study. Both the current study's salivary measure and the plasma measure used by Kelsch and colleagues (2013) employed the recommended extraction procedures for enzyme immunoassay (EIA) methods that are commercially available at present (McCullough et al., 2013); recent studies using the same assay protocols have detected significant positive correlations between plasma and saliva oxytocin concentration levels (Grewen et al., 2010; Hoffman, Brownley, Hamer, & Bulik, 2012). Moreover, experiments using the identical assay protocol as that used in the present study have found that, relative to placebo, intranasal oxytocin administration heightens salivary oxytocin levels and that salivary oxytocin levels remain elevated for up to 7 hours after administration, a lingering effect that seems unlikely to be due to oxytocin simply dripping down the back of the throat and thereby mingling with saliva (Huffmeijer et al., 2012; van Ijzendoorn, Bhandari, van der Veen, Grewen, & Bakermans-Kranenburg, 2012). In sum, although both plasma and assay methods demand ongoing refinement and critical scrutiny, there are grounds to consider the assay procedure adopted in the present study to be relatively reliable—not least of which is that the hypothesized link between spirituality and oxytocin was observed.

Although the present results accord with a considerable supporting literature, they should be considered preliminary pending replication with larger samples, including participants of multiple faiths, or who self-identify as spiritual but not religious. Further, whereas this study focused on endogenous oxytocin, administration paradigms might experimentally assess the causal direction of

Table 2
Simultaneous Linear Regression of Spirituality on Oxytocin, Controlling for Demographic and Affective Covariates

Demographics	B	*SE*	β	*p*
Spirituality	2.44	.90	.53	.01
Church attendance	−.31	1.01	−.06	.76
Positive affect	.28	.95	.06	.77
Sex	−.48	.98	−.10	.63
Relationship status	−.58	.59	−.19	.33

Note. $n = 34$.

the relationship between spirituality and oxytocin. In addition, because our study utilized a single-item assessment of spirituality, future research should adopt alternate measures of spirituality, including measures which tap distinct dimensions of spirituality using multiple items, and ensure that spirituality (i.e., a sense of connection with the sacred) and religiosity (i.e., endorsement of religious beliefs or participation in religious institutions) are methodologically disentangled (Hill et al., 2000). Whereas "spirituality" is conceptualized as involving a personal connection with God within our homogenous sample of devout Christians, clarifying how the term "spirituality" is interpreted, and whether or not this term truly indexes a cogent subjective experience, will be particularly important when moving to more diverse samples (Holbrook & Sousa, 2013). Indeed, cross-cultural investigations may reveal that the "spiritual" experiences of Christian samples in the United States are parochial, without universal psychological analogues, and thus without a universal basis in oxytocin systems (see Henrich, Heine, & Norenzayan, 2010). Finally, convergent behavioral and implicit measures should be used to confirm that participants' self-reported high spirituality reflects their genuine experience, as opposed to a canny self-presentation style in contexts wherein devout spirituality is socially valued. These future directions notwithstanding, the present findings provide the first empirical evidence linking spirituality to oxytocin in a nonclinical sample.

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