What Makes Women Happy: Oxytocin Release Correlates with Life Satisfaction

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Abstract

We present a biological model of happiness that identifies how variations in the physiology of connection impact life satisfaction. We find that the change in oxytocin after a trust stimulus was positively correlated with one's satisfaction with life after controlling for the stage of a woman's menstrual cycle. Highly satisfied women had more friends, were closer to their families, had more fulfilling romantic relationships, and had sex more frequently. These effects were mediated by attachment styles. We did not find evidence that childhood experiences, stress, or religious behaviors affected life satisfaction. Measures of hormones and relationship quality together explained 50% of the variation in life satisfaction. The model and data provide a new way to think about what makes women happy, and why well-being varies across individuals.

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Happiness is a perfume you cannot pour on others without getting a few drops on yourself. - Ralph Waldo Emerson

Introduction

What makes women happy? The pursuit of happiness is highly valued and often responsible for much of human behavior—it is after all enshrined in the U.S. Declaration of Independence. However, achieving a state of happiness is often difficult or even elusive for many people. As a consequence, what makes us happy has attracted the attention of philosophers, theologians, and scientists who have sought to provide guidance on how to attain what the Greek philosopher Aristotle called eudaimonia or flourishing (Haidt, 2005). Many of these traditions provide similar guidance to flourishing, often focusing on the quantity and quality of interpersonal and intimate relationships (Cyranowski et al., 2000; Haidt, 2001).

Herein, we develop a biological model of happiness and test the model's implications experimentally. The experiment provides evidence supporting some but not all of the model's implications for a sample of college-aged women. A primary focus of the model is the neurotransmitter and hormone oxytocin because it facilitates attachment to others and is associated with positive social behaviors (Zak, 2011). We have restricted our tests of the model to women because there is evidence showing that women and men form and maintain relationships in distinct ways (Maltz & Borker, 1982; Wood, 1993).
Relationships strongly influence people's satisfaction with their lives (Diener & Seligman, 2000). For instance, research on well-being has found that social relationships are the strongest correlates of positive emotions when examining 15 common daily activities (Kahneman et al, 2004). The positive association between relationship quality and well-being is supported by a large number of studies that have linked both social and romantic relationships to life satisfaction (House, Umberson, & Landis, 1988).

In our view and others', advancing the science of well-being necessitates linking relationships to their biological foundations (Ryff & Singer, 1998).

Biological Factors

The hormone oxytocin (OT) may be a mechanism through which social relationships produce well-being. In nonhuman mammals, OT has been associated with maternal care for offspring, toleration of burrow-mates (Donaldson and Young, 2008) and social recognition (Champagne, et al, 2003). Recent research has shown that among unacquainted humans, OT facilitates reciprocity after one has been trusted (Zak, et al., 2004; 2005), the expression of trust (Kosfeld et al. 2005; Kéri, Kiss, & Kelemen, 2009), generosity with money (Zak, Stanton & Ahmadi, 2007), and monetary sacrifice (Morhenn et al., 2008). The brain's release of OT has been correlated with the subjective experience of empathy (Barraza & Zak, 2009) and the infusion of synthetic OT increases
empathy (Domes et al., 2007a).

In mammals, especially group-living mammals like humans, OT is reliably released after a positive social stimulus (Zak, 2011). OT's effect on physiology and behavior occurs when it binds to its receptor. The number and locations of OT receptors depends on genetics and on an animal having received sufficient nurturing while young (Carter, 2003). Animals that are abused or neglected by caregivers have fewer OT receptors in the forebrain and tend to be socially withdrawn, anxious and neophobic (Meaney, 2001). There is some evidence that abuse in human beings produces a similar dysregulation in OT (Vercoe, 2009; Zak 2011).

In adults of both sexes, affectionate and stimulatory contact while playing with their infants has been associated with OT release (Feldman et al., 2010). First-time mothers who had a secure attachment style released more oxytocin when holding their infants and showed greater activation in dopaminergic mid-brain reward regions when cued by their infant's face. These effects were muted in mothers who had an insecure attachment style (Strathern et al., 2009). Further, exogenous OT infusion can increase the sense of attachment security (Buckheim et al., 2009). Children who are neglected or abused tend to have heightened hypothalamic-pituitary-adrenal (HPA) axis activity as adults (VanVoorhees & Scarpa, 2004). High stress levels, in turn, suppress the release of OT in both animals (Neumann & Bosch, 2008) and humans (Barraza & Zak, 2009).
This research indicates that an appropriately functioning OT system depends on one's childhood development and may affect one's relationships with others. Other biological factors that interact with OT may also affect relationships. For example, variations in estradiol and progesterone that occur over a women's menstrual cycle affect the number of OT receptors and uptake of OT (Verbalis, 1999; Grazzini et al., 1998). Consistent with this effect, women report greater life satisfaction during the late follicular phase of the menstrual cycle (just prior to ovulation) when estradiol is the highest; this is contrasted with women’s reported decrease in positive mood during the late luteal/premenstrual phase of their cycles (Dwyer, 2008; Gonda et al., 2008).

A Biological Model of Happiness

The interactions between personality traits, developmental history and physiologic factors that affect OT release have led us to develop a biological model of happiness (BMH). The BMH identifies how OT is likely to affect well-being and guided the design of our experiment and statistical tests. The model's focus is on the biology of attachment. The BMH is based on the notion that evolution is conservative and re-uses mechanisms that evolved for one purpose (e.g. care for offspring) for other similar purposes (e.g. attachment to friends). If correct, this means that OT release will mediate many types relationships. Indeed, OT release appears to occur for a larger variety of stimuli in humans compared to other mammals (Zak, 2011; Zak in press). Human beings even
become attached to other species and inanimate objects like cars.

Figure 1 illustrates the BMH. The model shows that the release of OT depends on genes, one's developmental history, and one's current physiologic state (Donaldson & Young, 2008; Hoge et al, 2008). Genes and development are posited to affect both the amount of OT released after stimulus as well as the number of OT receptors, while one's current state, especially stress levels, impact the uptake of OT by its receptor (Barraza & Zak, 2009; Jezová et al. 1996). OT release motivates the desire to interact with others and to form relationships.

The model also shows that OT release can affect happiness directly. OT release potentiates the release of two neurotransmitters, dopamine and serotonin, a brain circuit known as HOME (Human Oxytocin Mediated Empathy; Zak, 2011). This reinforces positive social interactions by providing a rewarding sensation (dopamine) and by reducing anxiety (serotonin) after positive social interactions. The HOME circuit provides feedback that can lead to greater well-being by inducing people to seek connections with others.

The model predicts that OT affects the ability to form and sustain relationships. In this paper, we focus on five kinds of relationships: romantic, attachments to parents, friendships, interactions with strangers, and connections to God or a transcendent other. Bowlby (1969) was among the first to posit that early relationships with caregivers can be characterized in terms of differing degrees of felt security and support. This development carries through to
adulthood and can affect relationship quality (Hazan & Shaver, 1987). The BMH posits that variations in OT release during social interactions will affect relationship quality by affecting the strength of attachment to others. Functionally, the BMH predicts that those who release more OT after a positive social stimulus will report greater satisfaction in their lives. This difference in life satisfaction, the model shows, is due to higher quality relationships.

We will briefly provide support our focus on five kinds of relationships that can influence well-being. Indeed, there is manifold evidence supporting the link between romantic relationships, friendships, and attachment to parents to satisfaction with life. These studies have shown that among the factors that influence eudaimonia, these relationships are the most important (Argyle 1987; Myers 1999; Diener & Biswas-Diener, 2008). Still, the topic of relationships is complex, and even close relationships are multifaceted, so specificity is warranted concerning what aspects of relationships produce satisfaction. Two concepts—attachment and intimacy—are especially relevant (Reis & Patrick 1996; Meyers, 1993).

In his review, Nezlek (2000) concluded that it is the quality of relationships, not the quantity, that is associated with well-being. Carstensen's (1998) Social Selectivity Theory, as well as work in Social-Determination Theory (SDT) (e.g. Kasser & Ryan, 1999) reach the same conclusion. Much of the research guided by SDT examines environmental factors that hinder or undermine self-motivation, social functioning, and personal well-being. Day-to-day variations in interactions
over a two-week period predicted positive affect and vitality, supporting SDT (Reis et al, 2000). The combination of these momentary interactions may play an important role in one’s determination of overall well-being (Kahneman, 2003). People who experienced greater relatedness, engaged in meaningful dialog, or had fun with others were happier, disclosed more emotionally relevant information to each other and responded appropriately when receiving these disclosures.

Many people also seek transcendent connections as sources of contentment and comfort. Witter et al. (1985) examined 556 studies and found 28 examined religion and subjective well-being, the latter variously measured by life satisfaction, morale, well-being, quality of life, and happiness. They found religion was positively associated with perceptions of well-being, especially among older people. A stronger association was found in earlier studies, suggesting a possible trend in which religion is becoming less important to life satisfaction. Studies indexing religious activity to well-being yielded stronger relationships than did other measures of religiosity. Overall, religion accounted for between two and six percent of the variance in adult subjective well-being.

Lastly, human beings engage in a variety of activities that benefit strangers at a cost to themselves. Many of these behaviors, often called virtues, are the same as those that sustain relationships (Peterson and Seligman, 2004). Studies have shown that OT release is associated with being trustworthy, generous, sacrificial with money, and empathic toward specific but unknown
others (Zak, 2011). Care for strangers even occurs at a distance; for example, infusing 40IU of OT caused people to donate 48% more money to charity to help unspecified others relative to those who received a placebo (Barraza, McCullough & Zak, 2011). Kindness to strangers is a temporary attachment that may increase one's satisfaction with life.

[Figure 1 here]

Materials and Methods

We ran an experiment to stimulate endogenous OT release using a paradigm our lab previous developed (Zak et al., 2004; 2005). During the experiment we assessed participants' developmental histories and stress levels to establish baseline factors that may impact OT release following the BMH. Participants' attachment styles and relationships were also appraised. In addition, the laboratory task allowed us to assess generosity toward a stranger with money earned in the experiment.

For the present paper, we do not measure the effect of genes on OT release. For the 275 known human oxytocin receptor single nucleotide polymorphisms (SNPs; National Center for Biotechnology Information, 2011), none have as yet been shown to affect OT release or uptake. Some OT receptor SNPs have been associated with personality traits such as empathy and behaviors such as altruism (Rodigues, et al, 2009; Israel et al, 2009) but their functional effects, if any, are currently unknown. We leave the direct relationship
between OT receptor SNPs and well-being for future research.

Participants and Procedures

Participants were recruited using email and flyers at the Claremont Colleges in Southern California. The protocol was approved by the Institutional Review Boards of Scripps College and Claremont Graduate University. All data were collected using an alpha-numeric identifier to maintain participant anonymity.

Sixty females (mean age = 22, SD = 5.6) volunteered to participate in the study. Each participant earned $10 for agreeing to join the experiment with total earnings contingent on the decision-making task described below. After providing written consent, participants were led to a private room for a blood draw to assess basal hormone levels. Participants were then seated at partitioned computer stations for privacy and were asked to fill out surveys discussed below.

Once all basal blood samples were obtained, participants were given written and verbal instructions and were asked to make decisions in a one-shot monetary decision task. No communication between participants was allowed. Immediately following each person's decision, a second blood draw was performed. Upon completion of the second blood draw, each participant was privately paid her earnings by a lab administrator who was not associated with the study.
Trust Game

In our previous studies of OT release in humans, no association has been found between basal OT and behaviors in the lab, or with basal OT and most personality traits (see Zak, 2011). Indeed, in animals there is little correlation between peripheral and central (brain) levels of basal OT. It is the release of OT after a stimulus that induces a coordinated release of peripheral and central OT (Wotjak, et al, 2008). As a result, an OT-releasing stimulus is needed to assess participants' change in OT that we hypothesized would be related to their relationship quality and life satisfaction.

In order to induce OT release, participants made a single decision in a dyadic monetary decision task known as the "trust game" (Berg et al., 1995). The trust game is designed to assess the behavioral effects of trust by a stranger and the degree of reciprocation of that trust. All participants received extensive instructions, including examples, before making their decisions. Participants' decisions determined their earnings, although without their knowledge, a minimum payment of $15 was used so that all volunteers were fairly compensated.

In the standard trust game, participants are randomly assigned to dyads. In each dyad, there is random assignment as Decision-Maker 1 (DM1) or Decision-Maker 2 (DM2). Both DMs receive $10 for participating and after identical instructions, DM1 is prompted by computer to send some amount of the $10 show up earnings, including zero, to the DM2 in the dyad. Whatever is sent
is removed from DM1’s account and is tripled in DM2’s account. Next, DM2 receives a computer message stating the transfer from DM1 and the total in his/her account. DM2 is then prompted by computer to make a return transfer to DM1 from zero to the total in the account. This concludes the task.

The consensus view in experimental economics is that the transfer from DM1 to DM2 is a measure of trust (Smith, 1998). This transfer is not thought to measure altruism because both DMs have the same earnings before the task and on debrief DM1s report that they transfer money to DM2s on the expectation of a return. Indeed, about 90% of DM1s transfer money to DM2s and 95% of DM2s return money (Zak, 2011). The return transfer from DM2 to DM1 measures trustworthiness or reciprocity. This task provides an objective measure via the money sent of the degree of trust in a stranger and subsequent trustworthiness.

We modified the trust game in the present experiment because the receipt by DM2 of an intentional monetary transfer denoting trust has been shown to induce a spike in OT (Zak et al., 2004; 2005; Morhenn et al., 2007). For this reason, all participants were assigned the role of DM2 in the trust game. Further, every DM2 received an identical OT-inducing stimulus, a $24 transfer from DM1. Participants were instructed that they could return any amount of money they wished to DM1 knowing that the amount will be taken out of their earnings.
Blood Draw

After consent, all participants had 20 ml of blood drawn by a licensed phlebotomist from an antecubital vein. Two 6-ml EDTA-treated whole blood tubes and one 8 ml serum-separator tube were drawn while maintaining a sterile field and using a Vacutainer® (BD, Franklin Lakes, NJ, USA). A second 20 ml blood draw was done immediately following each participant's decision in the trust game. Participants were randomly prompted by ID code to make their decisions sequentially to minimize the time between the decision and the blood draw due to OT's three minute half-life following previously published protocols (Zak et al., 2004; 2005). The time between the decision and blood draw was less than two minutes for all participants. Blood tubes were immediately placed on ice after being drawn. The tubes were then placed in a refrigerated centrifuge and spun at 1500 rpm for 12 min at 4C. Plasma and serum were removed from the tubes and aliquoted into 2 ml microtubes with screw caps. These tubes were immediately placed on dry ice and then transferred to a −80C freezer until analysis.

Assays

Five hormones were assayed using either radioimmunoassays (RIA) or enzyme-linked immunosorbent assays (ELISA). All tests were performed at the Biomarkers Core Laboratory of the Yerkes National Primate Research Center at Emory University, Atlanta, GA. Adrenocorticotropic hormone (ACTH; plasma-RIA), estradiol (E; serum-RIA) and cortisol (CORT; plasma-RIA) were assayed
using commercial kits from Diagnostic Systems Laboratories (Webster, TX). Progesterone (P; serum-RIA) was assayed using a kit from Diagnostic Products Corporation (Los Angeles, CA) and OT (plasma-ELISA) was assayed using a kit from R&D Systems (Minneapolis, MN). The inter- and intra-assay coefficients of variations were in acceptable ranges (ACTH: 15.4%, 6.8%, E: 11.3%, 17.6%; CORT: 4.5%, 4.9%, P: 11.7%, 7.8%, OT: 10.2%, 7.5%). Estradiol and progesterone were used to create an indicator of each women’s menstrual cycle (Baird & Fraser, 1974). Synthetic versions of these hormones are also commonly used for birth control. We gain additional statistical control by measuring them.

Surveys

Participants filled out several survey instruments prior to the OT-inducing task to assess their personal histories, behaviors, and well-being. Instruments included the Satisfaction With Life inventory (SWL; Diener, Emmons, & Griffin, 1985), Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996), Adult Attachment Scale (AAS; Hazan and Shaver, 1987), Religious Commitment Inventory (RCI; Worthington et al. 2003, Life Stressor Checklist (LSC-R; Wolfe & Levin, 1991), Experiences in Close Relationships-Revised (ECR-R; Fraley, Waller, and Brennan, 2000), along with questions on basic demographics taken from Zak, Kurzban & Matzner (2005).
Results

Figure 2 shows the change in OT for all participants after the trust stimulus. Three participants were excluded from analyses because basal levels of OT were outside of the acceptable assay range (>2500 pg/ml for a 2.5:1 dilution). The mean change in OT due to the trust stimulus was positive as in our previous studies (M: 5.9 pg/ml; SD: 138.74). Yet, this average masks the high variation in OT release across participants, from -44% to 85%.

The total SWL score varied from 10 to 35 on a 35-point scale (M: 26.6; SD: 6.3). This compares well to a nationally representative college sample (M: 23.7; SD 6.5; Pavot & Deiner, 1993) and a noncollege adult sample (M: 23.6; SD 6.1; Pavot et al., 1991). Fully 84% of women in the sample were somewhat to extremely satisfied with their lives, while 14% were somewhat to extremely dissatisfied (Figure 3).

Basal Factors

Following the BMH, we tested if OT release was modulated by current physiologic stress and childhood development. For this sample, there was no effect of two measures of stress on the change in OT (CORT: r = .04, p = .76; ACTH: r = -.18, p = .23). In addition, neither CORT nor ACTH were associated with SWL (CORT: r = .23, p = .12; ACTH: r = -.03, p = .88).

The impact of childhood development on OT release was assessed by examining resilience to adverse events. Those with less resilience to adverse
events had a smaller change in OT ($r = -.29$, $p = .045$).

OT Release and SWL

We next examined if OT release had a direct impact on happiness via the HOME circuit. As discussed above, a woman's menstrual cycle affects her happiness. To control for this effect, we designed indicators for the phase of a woman's menstrual cycle by using E and P levels. A woman was in the late follicular phase of the menstrual cycle if her $E > 100$ pg/ml and $P < 3$ pg/ml (10% of sample). We also identified the luteal phase of the menstrual cycle when $E > 100$ pg/ml and $P > 3$ pg/ml (6.7% of sample).

SWL was positively correlated with the change in OT ($r = .14$), but this effect was insignificant when the phase of menstrual cycle was not taken into account ($p = .35$). However, when controlling for a woman's menstrual cycle, the change in OT and SWL were positively related ($r = .31$, $p = .046$; Figure 4). The change in OT and menstrual cycle indicators explain 32% of the variation in SWL.

Relationships and SWL

The BMH predicts that OT release will be related to the quality of relationships. We first examined this issue by testing if OT release was associated with attachment styles. We did not find evidence that the change in OT was associated with attachment related anxiety ($r = -.10$, $p = .51$) or attachment
avoidance ($r=.02$, $p=.90$). We also tested if attachment styles had a direct effect on well-being. We found that attachment avoidance was associated with diminished SWL ($r = -.39$, $p = .008$), and attachment related anxiety also reduced SWL ($r = -.42$, $p = .003$). Women who were above the median for SWL had 12% less attachment related anxiety (3.4 vs. 3.9) and 28% less attachment related avoidance (2.1 vs. 2.9).

Those who had higher scores on attachment related avoidance had fewer close friends ($r = -.29$, $p = .04$). These women did not have diminished family relationships (average of three family questions; $r = -.20$, $p = .18$) nor reduced spiritual commitment ($r = -.07$, $p = .63$). Those who had higher attachment avoidance did not return less to the stranger who had trusted them ($r = -.23$, $p = .12$) and did not have fewer sexual partners than others ($r = -.20$, $p = .17$), but did have less sex per month ($r = -.30$, $p = .04$).

Those with an anxious attachment style had a trend toward fewer friends ($r = -.24$, $p = .10$) and lower quality family relationships ($r = -.26$, $p = .07$). They did not, though, return less money to a stranger ($r = -.19$, $p = .19$), or report a diminished spiritual relationship ($r = .18$, $p = .22$). Those who scored high on attachment related avoidance did not have fewer sexual partners than others ($r = -.19$, $p = .19$), but did have significantly less sex per month ($r = -.45$, $p < .01$). Attachment related avoidance and attachment related anxiety were significantly correlated ($r = .62$, $p < .01$).

Next, we investigated how specific relationship types affected well-
being, starting with romantic relationships. Those who had a steady relationship with a boyfriend or girlfriend trended towards a higher SWL ($r = .26$, $p = .07$), and had significantly more sex per month ($r = .80$, $p < .01$). Indeed, SWL was positively correlated with sexual frequency ($r = .29$, $p = .047$), and use of birth control ($r = .42$, $p = .004$). A median split by SWL showed that those who were more satisfied with their lives had almost twice as much sex per month (8.6 vs. 4.5). A median split by number of sexual partners showed that those with fewer partners released an average of 48pg/ml of OT when trusted, while those with the fewest partners had an average decrease in OT of 44pg/ml after the trust stimulus.

We also tested the effect of family relationships on SWL. We found that well-being was positively correlated with the amount of togetherness with family and friends ($r = .60$, $p < .001$; 5 point scale), the support and understanding family and friends ($r = .55$, $p < .001$; 5 point scale), and time spent discussing issues with family and friends ($r = .49$, $p < .001$; 5 point scale). We found an overall negative effect of the number of siblings on SWL ($r = -.33$, $p = .02$). However, the data reveal a curvilinear, inverted U shape, with between two and three siblings producing the highest SWL.

Friendships are also appeared to be associated with well-being. The number of close friends showed a positive trend with SWL ($r = .27$, $p = .064$). A median split by SWL showed that those who were more satisfied had almost 50% more friends (8.5 vs. 5.8) than those who are less satisfied. SWL was unrelated
to the gender of one's best friend (r=.08, p=.57). The data revealed a strong positive correlation between those who reported that they are friends with themselves and SWL (r=.61, p<.001).

Because people commonly interact with strangers, we tested if this type of interaction increased well-being. We found that SWL was correlated with reciprocity of money to the stranger who had trusted them (r = .31, p = .029). A median split by SWL showed that those who were more satisfied returned 37% more money to a stranger ($14.69 vs. $10.70).

The final relationship type we tested was transcendent relationships. SWL did not correlate with religious commitment in this sample is (r = -.05, p = .72). Indeed, SWL was not associated with any of the religious behavior measures we used, including reading religious material (p=.40), donations to a religious organization (p=.40), religious study (p=.19), religion as a search for meaning (p=.76) or life guidance (p=.82), time spent with members of one's religion (p=.52), religious reflection (p=.40), or religious volunteering (p=.54).

Putting all five relationship indicators together in a least squares regression, we are able to explain 45% of the variation in SWL. When we include the change in OT, menstrual cycle indicators and attachment styles, we explain 50% of the variation in SWL.

Additional Effects on SWL

We also examined other factors not predicted by the BMH to see if
they affected SWL. We found that satisfied women drank less alcohol per month ($r = -0.40$, $p = .005$). Satisfied women also exhibited fewer depressive symptoms ($r = -0.77$, $p < .001$) and greater resilience ($r = .51$, $p < .001$). A median split by SWL showed that those who were more satisfied had 31% fewer depressive symptoms (23.5 vs. 31.3; maximum score 66) and 11% greater resilience (6.0 vs. 5.4; 7 point scale). There were no significant correlations between SWL and individual characteristics such as age ($p = .31$), weight ($p = .79$), or sexual orientation ($p = .79$).

Discussion

One of the mysteries in positive psychology is why everyone is not fully satisfied with their lives. Estimates attribute 50% or more of life satisfaction to one's genes and personality traits (Lykken & Tellegen, 1996). This means that the other half of happiness depends on actions we take. But why doesn't everyone take these actions? The research reported here indicates that people vary in their ability to form and sustain relationships based on variations in the release of OT. We showed that oxytocin, menstrual cycle and the five relationship types identified in the BMH explain 50% of variation in SWL. We also found a direct link from the release of OT to happiness. The largest effect on SWL came from family relationships. This is perhaps unsurprising given the age of the sample tested. The other relationships types that increased SWL were, in order of largest impact: interactions with a stranger, romantic relationships, and
friendships. Transcendent relationships did not, in this sample, contribute to life satisfaction.

Previous research has found that those with high scores for satisfaction with life have higher self-esteem, are less neurotic, spend more time being happy, and are more sociable (Diener et al., 1985). These people also score higher on trait measures of agreeableness, trust, altruism, and tender-mindedness and exhibit greater gratitude (Wood, Joseph & Maltby, 2008). Why participants reciprocated money to a stranger who had trusted them in the present study provides some clues regarding how highly satisfied people approach relationships. Those who returned more money to a stranger tended to trust others \( (r = .41, p < .01) \), believed that most people can be trusted \( (r = .41, p < .01) \), and reported that most people are basically honest \( (r = .30, p < .01) \). Participants who were trustworthy toward others were significantly less focused on money \( (r = -.42, p < .01) \) and were more likely to reject the notion that there are no right and wrong ways to make money \( (r = -.40, p < .01) \). Reciprocation was also associated with less attachment related avoidance \( (r = -.33, p < .05) \). These attitudes and behaviors indicate that participants had built relationship-centered lives. Indeed, when asked if their lives had meaning, this question was positive associated with life satisfaction \( (r=.52, p<.001) \).

Our findings support interventions to improve well-being through activities that improve the quality of relationships (Fordyce, 1977, 1983; Lyubomirsky, Sheldon & Schkade, 2005; Lyubomirsky, 2008; Fredrickson, 2001).
These researchers found positive effects on well-being by those who spent more time socializing and performing purposeful acts of kindness. The findings of Lyubomirsky and colleagues (2005) suggest that well-being is enhanced when one performs these activities expressly for the purpose of increasing one’s quality of life. The research on OT indicates that kindness towards others will cause the brains of the recipients of these acts to release OT. This will then motivate the reciprocation of positive social behaviors, producing the release of OT in the initiator’s brain. Our findings here suggest that this positive feedback loop, from well-being enhancing activities with others, to a change in OT, to additional social activities, is the foundation for sustaining *eudaimonia*.

The high level of explained variation between the change and OT and relationships on SWL suggests that the causation may flow both directions. We cannot test if there is a bidirectional response in the present study, but the use of longitudinal data would resolve this. This study also needs to be repeated for men; we anticipate similar results, but because testosterone inhibits OT binding (Insel, Young, Witt & Crews, 1993), the relationship between OT and SWL in men may be different than we have found for women.

The findings here can be put to practical use. There is evidence from animal studies that the HOME system that modulates OT release can be tuned to a different “set point” (Carter & Keverne, 2002) where OT release is more likely to occur after a positive social stimulus. If this is the case, then having a high quality relationship of one type may reduce the threshold for OT release for other
positive social stimuli. This may enable individuals to form higher quality relationships of all types, and through this route, improve satisfaction with life. In other words, relationships may “train the brain” to release more OT in ways that could make us happier. Our findings indicate that intentionally focusing on behaviors, such as providing others with unexpected kindesses that improve relationship quality, are an effective route to enhance one's quality of life.
References


Figures

Figure 1. A biological model of happiness in which one's genes, developmental history and basal physiologic state effect the release of OT after a positive social stimulus. The change in OT affects one's attachment style, while attachment style impacts five types of relationships that affect SWL. The change in OT also affects happiness directly via the HOME circuit.
Figure 2: The change in OT varied from -44% to 85%, with mean change of 5.9 pg/ml after participants received a monetary transfer of $24 from a stranger denoting trust. This stimulus was used because being trusted had previously been shown to raise OT. Nearly half (42%) of the women in the sample had a decrease in OT after being trusted.
Figure 3. The distribution of satisfaction with life for women in the sample. More than one and a half times as many women were extremely satisfied to satisfied compared to those who were dissatisfied (36% vs. 14%). No one reported being extremely dissatisfied.
Figure 4. The relationship between the change in OT and satisfaction with life after controlling for participants' menstrual cycles. There is a positive relationship ($r = .31, p< .05$) between the change in OT and SWL. The graph shows that relationship has a larger variance for women with low SWL.
Figure 5. A median split of the number of sexual partners in the last five years shows that women with more sexual partners had an average decrease in OT after being trusted of 44%. Conversely, women with fewer sexual partners had an average increase in OT after the trust stimulus of 48%.