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ACUTE AND CHRONIC PHYSIOLOGICAL CONSEQUENCES OF SOCIAL REJECTION

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The Ugly Duckling, written by Danish poet Hans Christian Andersen, tells the story of a homely bird and his experiences with social ostracism before maturing into a beautiful swan. Andersen (1844) captured the duckling's profoundly painful reflection of his loneliness and victimization in a short soliloquy:

> It does not matter: better be killed by them than pecked by the ducks, beaten by the hens, pushed about by the maiden who feeds the poultry, or starved with hunger in the winter
>
> (p. 15)

It is not difficult to empathize with the duckling, who in addition to enduring significant physical abuse, also experiences extensive social rejection. A large body of evidence suggests that social ostracism causes individuals to sustain devastating psychological and physiological consequences (Williams & Nida, 2011). Evolutionarily, exclusion from the group often reduced reproductive success and increased the risk of premature death as a result of food shortages and inadequate protection from predators and adversaries (Ainsworth, 1989; Buss, 1990, 1991). Naturalistic observations suggest that banished or evicted animals experience significantly greater risk of injury and mortality in comparison to animals whose group membership remains intact (Cant, Otali, & Mwanguhya, 2001; Lancaster, 1986; Robbins & Robbins, 2005). Among humans, mental and physical health are strongly influenced by the quality of one's social networks (e.g., Aldabe et al., 2011; Wilkinson & Marmot, 2003). The core of social exclusion threatens humans' most fundamental needs of belonging, control and self-esteem (Williams, 2002) and confers both acute consequences such as negative mood and heightened physiological arousal, as well as long term

consequences such as chronic dysregulation of the HPA axis, decreased immune function, and increased risk of disarmingly wide variety of serious diseases following prolonged social exclusion. It is not surprising, perhaps, that humans possess a deep motivation to establish and maintain lasting connections with their conspecifics (Baumeister & Leary, 1995), and will often exercise extraordinary efforts to avoid being ostracized (Williams & Nida, 2011).

Acute Consequences of Social Rejection, Exclusion and Ostracism

Baumeister and Leary (1995) theorized that humans have a pervasive "need to belong" (p. 497). In fact, this need is so extensive that it has led to the development of distinct cultural rituals in terms of the way people speak and dress in order to identify themselves to in-group members and distinguish themselves from out-group members (Over & Carpenter, 2009). When individuals' fulfillment of the need to belong is threatened, they experience profound psychological distress and pain. A seminal functional magnetic resonance imaging study demonstrated that the same brain regions implicated in the experience of physical pain are activated during social rejection (Eisenberger, Lieberman, & Williams, 2003). Unlike physical pain however, social pain is relived each time the memory is recalled (Chen, Williams, Fitness, & Newton, 2008).

In addition to neural activation, social exclusion also initiates a cascade of physiological changes very similar to those evoked by a perceived environmental threat. The perception of threat recruits the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. The activation of the SNS results in the rapid release of the catecholamines epinephrine and norepinephrine from the locus coeruleus (Chrousos, 2009; Pacak, 2000), and leads to increases in heart rate, blood pressure and blood glucose levels. Relative to the SNS, the HPA axis responds more slowly. The release of corticotropin releasing hormone and other neuromodulators from the paraventricular nucleus of the hypothalamus results in the release of adrenocorticotropic hormone from the anterior pituitary gland, ultimately leading to the secretion of the glucocorticoid cortisol from the adrenal cortex. Given the negative consequences of ostracism, it is not surprising that social evaluative threats evoke a particularly sharp in rise in cortisol concentrations (Andrews et al., 2007; Dickerson & Kemeny, 2004; Kirschbaum, Pirke, & Hellhammer, 1993). Although cortisol's primary function is gluconeogenesis (with the increase in blood glucose providing the body with a critical source of energy used to mount a fight or flight response), cortisol freely crosses the blood brain barrier, exerting regulatory control over various neuropeptides (e.g., neuropeptide Y) and neurotransmitters (e.g., acetylcholine, dopamine, glutamate, norepinephrine, serotonin) involved in the human stress response.

Interestingly, without the threat of social exclusion in tow, being alone is not sufficient to trigger the acute stress response linked to ostracism. In a now-classic rejection/acceptance paradigm, Blackhart, Eckel, and Tice (2007) demonstrated

that telling participants that no one wanted to work with them was sufficient to keep cortisol levels elevated for 45 minutes, in comparison to a control condition in which participants were assigned to working alone. Furthermore, socially rejected individuals are more accurate at assessing genuine versus deceptive expressions of social affiliation, suggesting that rejection increases the salience of opportunities for belonging and enhances vigilance for future rejection (Bernstein, Young, Brown, Sacco, & Claypool, 2008).

Sex Differences in Social Exclusion

Benenson, Markovits, Thompson, and Wrangham (2011) proposed that social exclusion is a specific type of relational aggression that is particularly salient to women, and as a result, their self-construal is more closely tied to social acceptance (Cross & Madson, 1997). Furthermore, women are thought to experience greater distress following social exclusion because of increased rumination following negative events (Nolen-Hoeksema, Larson, & Grayson, 1999) and the attribution of these experiences to a lack of personal competence (Rose & Rudolph, 2006). Using the Yale Interpersonal Stressor Task (Stroud, Tanofsky-Kraff, Wilfley, & Salovey, 2000), in which two trained confederates gradually exclude and reject a participant during two interactions, Stroud, Salovey, and Epel (2002) found greater levels of cortisol secretion and higher blood pressure in women compared to men, even though no gender differences in self-reported distress were reported. These results are particularly noteworthy given that in response to most laboratory stress tasks including public speaking and mental arithmetic (Kirschbaum et al., 1993; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004) as well as "real-world" examination stress (Frankenhaeuser et al., 1978), men tend to show greater secretion of both adrenocorticotropic hormone and cortisol.

Testosterone, Progesterone, and a More Inclusive Role of the Endocrine System in Social Exclusion

Testosterone

Aside from changes in cortisol secretion, differential levels of gonadal hormones such as testosterone and progesterone have also been observed in response to social exclusion. Testosterone, a steroid hormone regulated by the HPA axis, has been positively correlated with aggressive and dominant behaviors in both human and non-human animals, especially in situations in which social status is threated (Anestis, 2006; Archer, 2006; Beehner, Bergman, Cheney, Seyfarth, & Whitten, 2006; Ehrenkranz, Bliss, & Sheard, 1974; Mehta, Jones, & Josephs, 2008; Mehta & Josephs, 2010). Elevated levels of endogenous testosterone have been associated with reactive aggression following social exclusion (Geniole, Carré, & McCormick, 2011). Similarly, Peterson and Harmon-Jones (2012) found that

endogenous levels of testosterone positively predicted the subjective experience of anger following social exclusion. The authors hypothesized that anger and testosterone may be associated with "attempts to exert power, control, and dominance over others" (Peterson & Harmon-Jones, 2012, p. 901), particularly in the event of social ostracism, in which anger may fuel behaviors directed at regaining social control (Peterson, Gravens, & Harmon-Jones, 2011; Warburton, Williams, & Cairns, 2006). Lastly, Josephs et al. (2012) demonstrated that the association between testosterone and responses to threat of social exclusion was moderated by differences in the functional polymorphism in the promoter region of the serotonin transporter (5-HTT) gene (*SLC6A4*), such that 5-HTTLPR S carriers with higher levels of testosterone are more sensitive to social exclusion and experience an exaggerated stress response following social exclusion compared L carriers with lower levels of testosterone.

Progesterone

Whereas testosterone has been associated with aggressive and dominant behaviors, progesterone, another steroid hormone regulated by HPA axis has been linked with individual differences in affiliative motivation (Schultheiss, Dargel, & Rohde, 2003; Wirth & Schultheiss, 2006). Women taking oral contraceptives containing a progesterone derivative show higher levels of affiliative motivation in comparison to naturally cycling women (Schultheiss et al., 2003). In the animal literature, increases in affiliative behavior is strongly correlated with circulating levels of progesterone in female rats (Frye, Petralia, & Rhodes, 2000). Moreover, when the progesterone metabolite allopregnanolone is blocked, rats' tendency to seek social contact with conspecifics dramatically decreases (Frye et al., 2006).

Following threats of social exclusion, Maner et al. (2010) demonstrated that changes in progesterone secretion are highly dependent on individual differences in social anxiety and rejection sensitivity. Specifically, individuals high in social anxiety showed a substantial decrease in progesterone secretion following exclusion, a pattern consistent with the need to withdraw from others in order to protect themselves from further rejection and to conserve resources for future social interactions (Allen & Badcock, 2003; Maner et al., 2010; Molden, Lucas, Gardner, Dean, & Knowles, 2009). Conversely, individual high in rejection sensitivity showed a considerable increase in progesterone secretion following exclusion, suggesting that rejection-sensitive individuals may be highly motivated to seek out compensatory social acceptance and closeness from others following ostracism (Maner et al., 2010; Zwolinski, 2012). In fact, research suggests that social exclusion may increase pro-social behavior (Carlson & Miller, 1987; Cialdini & Kenrick, 1976; Williams & Sommer, 1997) and the need to affiliate (Maner et al., 2010). Williams, Cheung, and Choi (2000) demonstrated that following ostracism, individuals are more likely to engage in appeasing behavior and conform to the opinions of others in order to gain social acceptance. Similarly, following significant

threats to social status, such as the death of a close relative, female chacma baboons (Papio hamadryas ursinus) demonstrate an increase in both grooming rate and the number of grooming partners (Engh et al., 2006). It seems that, in order to attenuate stress and compensate for immediate loss, female chacma baboons engage in more communal behaviors to strengthen social relationships (Engh et al., 2006). In humans, rejected individuals display a heighten sensitivity for social cues signaling acceptance (Bernstein et al., 2008; DeWall, Maner, & Rouby, 2009) and react more generously toward individuals who may be good candidates with whom to develop a friendship (Maner, DeWall, Baumeister, & Schaller, 2007).

Chronic Consequences of Social Rejection, Exclusion and Ostracism

To this point, our discussion has centered on acute effects of social exclusion. Effects of chronic exclusion, on the other hand, highlights the critical importance of the need to belong (Baumeister & Leary, 1995). Social support buffers an individual from acute stress, and the negative consequences of exposure to chronic stress. By and large, these protections are missing when an individual is socially excluded (Weik, Maroof, Zöller, & Deinzer, 2010). Social support has been associated with an attenuated cortisol response following stressful events (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003; Kirschbaum, Klauer, Filipp, & Hellhammer, 1995), decreased incidence of mental illness (Kessler & McLeod, 1985; Taylor & Brown, 1988), and increased longevity (Berkman & Syme, 1979; Cohen & Wills, 1985; Kawachi et al., 1996). In contrast, a lack of social support has been associated with anxiety disorders (Torgrud et al., 2004), mood disorders (Leary, 1990), cardiovascular disease (Sorkin, Rook, & Lu, 2002), and immunoincompetence (Kiecolt-Glaser et al., 1984).

Effects of Ostracism, Social Support, and Social Isolation on HPA Axis Function — Consequences for Disease

Social Anxiety

When primed with the idea of persistent and enduring social exclusion (e.g., being told that their personality profile confers lasting loneliness throughout adulthood), individuals often experience increases in self-defeating behavior (Twenge, Catanese, & Baumeister, 2002) and decreases in self-esteem (Leary, Tambor, Terdal, & Downs, 1995). Through interviews with victims of chronic ostracism, Zadro (2004) found that these individuals appear to have accepted feelings of worthlessness and alienation, and in fact will often engage in self-ostracism in what seems to be misguided attempts to protect themselves from further victimization and rejection. Individuals with Social Anxiety Disorder (SAD) often engage in similar avoidant behaviors in order to shelter themselves from situations in which they may be exposed to the scrutiny of others (Condren, O'Neill, Ryan, Barrett,

& Thakore, 2002). Extensive human and animal research demonstrates that hyperactivity of the HPA axis has been associated with socially avoidant behavior (Roelofs, Elzinga, & Rotteveel, 2005). In primates, olive baboons (*Papio anubis*) with elevated basal and reactive HPA activity demonstrated significantly greater social avoidance and behavioral inhibition compared troupe members with overall HPA activity (Sapolsky, 1990). Similarly, in humans, increased HPA activity in healthy individuals has been associated with selective attentional bias for threatening social cues and increased social avoidance (Roelofs, Bakvis, Hermans, van Pelt, & van Honk, 2007; Roelofs et al., 2005; van Honk et al., 1998, 2000).

More recently, Roelofs et al. (2009) demonstrated that patients with SAD showed greater cortisol responses to a social stressor and subsequent avoidance of socially threatening stimuli compared to both healthy controls and patients with Post-Traumatic Stress Disorder. Further, cortisol response predicted the increase in social avoidance tendencies during stress in patients with SAD. Moreover, this effect remained even after controlling for possible confounds such as gender and medication. Collectively, these and other studies suggest that the hyperactivity of the HPA axis may contribute to increased avoidant behavior and decreased social competence, resulting in the maintenance of social anxiety and self-ostracism.

Extensive evidence suggests that loneliness is strongly associated with increased activity of the HPA axis. Individuals who are chronically alone demonstrate elevated mean salivary cortisol levels throughout the day compared to their sociable counterparts (Cacioppo et al., 2000). Similarly, Steptoe, Owen, Kunz-Ebrecht, and Brydon (2004) demonstrated that social isolation was significantly, positively correlated with cortisol awakening response (CAR), a neuroendocrine response characterized by a marked increase in cortisol secretion in the first 30 to 40 minutes following awakening (Pruessner et al., 1997), even after adjusting for waking cortisol value, sex, socioeconomic status, smoking, time of waking and body mass. Finally, elevated morning cortisol secretion has been shown to predict clinical depression (Goodyer, Tamplin, Herbert, & Altham, 2000; Halligan, Herbert, Goodyer, & Murray, 2007; Harris et al., 2000).

Depression

Clinical depression, better known as Major Depressive Disorder (MDD) is a debilitating mental illness characterized by significant distress, lost productivity and increased risk for suicidality (American Psychiatric Association, 2013). Dysregulation of the HPA axis is widely assumed to be linked to both the onset and the maintenance of MDD (Nemeroff & Vale, 2005; Plotsky, Owens, & Nemeroff, 1998). Various cross-sectional studies have found associations between the presence of MDD and alterations of the HPA axis, including elevated cortisol secretion (Chrousos & Gold, 1992), higher levels of corticopropin releasing hormone (Ehlert, Gaab, & Heinrichs, 2001), impaired negative feedback of the HPA axis (Thase, Jindal, & Howland, 2002), and alterations in morning

awakening cortisol (Huber, Issa, Schik, & Wolf, 2006). Perhaps the most effective buffer against the HPA axis dysregulation is the presence of social support (Cohen & Wills, 1985; Koolhaas et al., 2011). Unfortunately, at present it is unclear whether alterations of the HPA axis reflect consequences of MDD, or whether they reflect a general susceptibility to mood disorders that are present prior to the emergence of psychopathology (Bhagwagar & Cowen, 2008). There is some scant evidence supporting the hypothesis that individuals at greater risk for MDD (e.g., a first degree relative with MDD) demonstrate alterations of the HPA axis prior to the development of a mood disorder (Mannie, Harmer, & Cowen, 2007). If true, then social support, and by extension social exclusion become critical risk factors in the development of MDD (Allen & Badcock, 2003).

Immunocompetence

Chronic activation of the stress response caused by psychosocial stressors increases chronic disease risk, exacerbates preexisting conditions such as hypertension, atherosclerosis, insulin-resistant diabetes, immune suppression, and increases susceptibility to acute, infectious diseases (Bolger, Foster, Vinokur, & Ng, 1996; Miller, Kemeny, Taylor, Cole, & Visscher, 1997; Pressman et al., 2005; Sapolsky, Romero, and Munck, 2000). Evidence supporting a role for social connectedness in immunocompetence is emerging. For example, after controlling for age, gender and health status, individuals with fewer social connections are 2.5 times more likely to die from the same illness compared to those with the more connections (Kawachi et al., 1996; Sapolsky, 1994). Kiecolt-Glaser et al. (1984) found that loneliness was associated with a reduction in natural killer cell activity and overall immunocompetence. Capitanio, Mendoza, Lerche, and Mason (1998) showed that socially isolated rhesus macaques (*Macaca mulatta*) infected with simian immunodeficiency virus had higher glucocorticoid levels, fewer antibodies against the virus and a greater mortality rate, compared to those not socially isolated. Poorer immune function was found among women suffering from various forms of close, personal disruption, including divorce and separation (Kiecolt-Glaser et al., 1987). Finally, and perhaps most disturbing, Leserman et al. (2000) found that speed of progression from human immunodeficiency virus infection (HIV) to full acquired immunodeficiency syndrome (AIDS) was associated with higher serum cortisol *and* a lack of satisfactory social support. Collectively, these studies demonstrate that isolated and rejected individuals are more likely to exhibit dysregulation of the HPA axis and are at increased risk for the emergence and progression of a host of serious and fatal illnesses.

Conclusion and Future Directions

The core of social exclusion, unlike most other negative social interactions, lies in its threat of humans' most fundamental needs; specifically, the need to belong,

the need for control, the need for self-esteem, and the need for meaningful existence (Williams, 2002). Whereas immediate response to social exclusion includes negative mood, heightened physiological arousal and hostility, prolonged social exclusion and the resulting social isolation has been linked to chronic dysregulation of the HPA axis, decreased immune function, and increased risk of disarmingly wide variety of serious diseases.

By and large, the field of psychoneuroendocrinology—the clinical study of hormone fluctuations and their relationship to human behavior—is still in its early stages. As a result, the complete hormonal underpinnings of both acute and prolonged consequences of social rejection have yet to be fully mapped out. It would be especially revealing to examine individual differences that may confer protection against the negative consequences of social rejection, such as particular cognitive styles or coping mechanisms. Findings from these studies have the potential of providing foundational data for empirically supported clinical interventions. Moreover, while most studies tend to evaluate social rejection from the perspective of the target, or the individual experiencing rejection, it would be interesting to examine social rejection from the perspective of the perpetrator. Studies in this realm have significant implications in reducing bullying and related behaviors, and provide greater general understanding of why individuals engage in social rejection.

References

Ainsworth, M. S. (1989). Attachments beyond infancy. *American Psychologist*, *44*, 709.

Aldabe, B., Anderson, R., Lyly-Yrjänäinen, M., Parent-Thirion, A., Vermeylen, G., Kelleher, C. C., & Niedhammer, I. (2011). Contribution of material, occupational, and psychosocial factors in the explanation of social inequalities in health in 28 countries in Europe. *Journal of Epidemiology and Community Health*, *65*, 1123–1131.

Allen, N. B., & Badcock, P. B. (2003). The social risk hypothesis of depressed mood: Evolutionary, psychosocial, and neurobiological perspectives. *Psychological Bulletin*, *129*, 887.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed., *DSM-5*). Washington, DC: American Psychiatric Association.

Andersen, H. C. (1844). *The ugly duckling*. Copenhagen: C.A. Reitzel.

Andrews, J., Wadiwalla, M., Juster, R. P., Lord, C., Lupien, S. J., & Pruessner, J. C. (2007). Effects of manipulating the amount of social-evaluative threat on the cortisol stress response in young healthy men. *Behavioral Neuroscience*, *121*, 871.

Anestis, S. F. (2006). Testosterone in juvenile and adolescent male chimpanzees (Pan troglodytes): Effects of dominance rank, aggression, and behavioral style. *American Journal of Physical Anthropology*, *130*, 536–545.

Archer, J. (2006). Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neuroscience and Biobehavioral Reviews*, *30*, 319–345.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497.

Beehner, J. C., Bergman, T. J., Cheney, D. L., Seyfarth, R. M., & Whitten, P. L. (2006). Testosterone predicts future dominance rank and mating activity among male chacma baboons. *Behavioral Ecology and Sociobiology*, *59*, 469–479.

Benenson, J. F., Markovits, H., Thompson, M. E., & Wrangham, R. W. (2011). Under threat of social exclusion, females exclude more than males. *Psychological Science*, *22*, 538–544.

Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance, and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology*, *109*, 186–204.

Bernstein, M. J., Young, S. G., Brown, C. M., Sacco, D. F., & Claypool, H. M. (2008). Adaptive responses to social exclusion social rejection improves detection of real and fake smiles. *Psychological Science*, *19*, 981–983.

Bhagwagar, Z., & Cowen, P. J. (2008). "It"s not over when it's over': Persistent neurobiological abnormalities in recovered depressed patients. *Psychological Medicine*, *38*, 307.

Blackhart, G. C., Eckel, L. A., & Tice, D. M. (2007). Salivary cortisol in response to acute social rejection and acceptance by peers. *Biological Psychology*, *75*, 267–276.

Bolger, N., Foster, M., Vinokur, A. D., & Ng, R. (1996). Close relationships and adjustments to a life crisis: The case of breast cancer. *Journal of Personality and Social Psychology*, *70*, 283.

Buss, D. M. (1990). The evolution of anxiety and social exclusion. *Journal of Social and Clinical Psychology*, *9*, 196–201.

Buss, D. M. (1991). Evolutionary personality psychology. *Annual Review of Psychology*, *42*, 459–491.

Cacioppo, J. T., Ernst, J. M., Burleson, M. H., McClintock, M. K., Malarkey, W. B., Hawkley, L. C., & Berntson, G. G. (2000). Lonely traits and concomitant physiological processes: The MacArthur social neuroscience studies. *International Journal of Psychophysiology*, *35*, 143–154.

Cacioppo, J. T., & Hawkley, L. C. (2003). Social isolation and health, with an emphasis on underlying mechanisms. *Perspectives in Biology and Medicine*, *46*, S39–S52.

Cant, M. A., Otali, E., & Mwanguhya, F. (2001). Eviction and dispersal in co-operatively breeding banded mongooses (Mungos mungo). *Journal of Zoology*, *254*, 155–162.

Capitanio, J. P., Mendoza, S. P., Lerche, N. W., & Mason, W. A. (1998). Social stress results in altered glucocorticoid regulation and shorter survival in simian acquired immune deficiency syndrome. *Proceedings of the National Academy of Sciences*, *95*, 4714–4719.

Carlson, M., & Miller, N. (1987). Explanation of the relation between negative mood and helping. *Psychological Bulletin*, *102*, 91.

Chen, Z., Williams, K. D., Fitness, J., & Newton, N. C. (2008). When hurt will not heal exploring the capacity to relive social and physical pain. *Psychological Science*, *19*, 789–795.

Chrousos, G. P. (2009). Stress and disorders of the stress system. *Nature Reviews Endocrinology*, *5*, 374–381.

Chrousos, G. P., & Gold, P. W. (1992). The concepts of stress and stress system disorders: Overview of physical and behavioral homeostasis. *Journal of the American Medical Association*, *267*, 1244–1252.

Cialdini, R. B., & Kenrick, D. T. (1976). Altruism as hedonism: A social development perspective on the relationship of negative mood state and helping. *Journal of Personality and Social Psychology*, *34*, 907.

Cohen, S., Doyle, W. J., Skoner, D. P., Rabin, B. S., & Gwaltney, J. M. (1997). Social ties and susceptibility to the common cold. *Journal of the American Medical Association*, *277*, 1940–1944.

Cohen, S., Tyrrell, D. A., & Smith, A. P. (1991). Psychological stress and susceptibility to the common cold. *New England Journal of Medicine*, *325*, 606–612.

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, *98*, 310.

Cole, S. W., Korin, Y. D., Fahey, J. L., & Zack, J. A. (1998). Norepinephrine accelerates HIV replication via protein kinase A-dependent effects on cytokine production. *The Journal of Immunology*, *161*, 610–616.

Condren, R. M., O'Neill, A., Ryan, M. C. M., Barrett, P., & Thakore, J. H. (2002). HPA axis response to a psychological stressor in generalised social phobia. *Psychoneuroendocrinology*, *27*, 693–703.

Cross, S. E., & Madson, L. (1997). Models of the self: Self-construals and gender. *Psychological Bulletin*, *122*, 5.

Cyranowski, J. M., Frank, E., Young, E., & Shear, M. K. (2000). Adolescent onset of the gender difference in lifetime rates of major depression: A theoretical model. *Archives of General Psychiatry*, *57*, 21–27.

DeWall, C. N., Maner, J. K., & Rouby, D. A. (2009). Social exclusion and early-stage interpersonal perception: Selective attention to signs of acceptance. *Journal of Personality and Social Psychology*, *96*, 729.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*, 355.

Ehlert, U., Gaab, J., & Heinrichs, M. (2001). Psychoneuroendocrinological contributions to the etiology of depression, posttraumatic stress disorder, and stress-related bodily disorders: The role of the hypothalamus–pituitary–adrenal axis. *Biological Psychology*, *57*, 141–152.

Ehrenkranz, J., Bliss, E., & Sheard, M. H. (1974). Plasma testosterone: Correlation with aggressive behavior and social dominance in man. *Psychosomatic Medicine*, *36*, 469–475.

Eisenberger, N. I., Lieberman, M. D., & Williams, K. D. (2003). Does rejection hurt? An fMRI study of social exclusion. *Science*, *302*, 290–292.

Engh, A. L., Beehner, J. C., Bergman, T. J., Whitten, P. L., Hoffmeier, R. R., Seyfarth, R. M., & Cheney, D. L. (2006). Behavioural and hormonal responses to predation in female chacma baboons (Papio hamadryas ursinus). *Proceedings of the Royal Society B: Biological Sciences*, *273*, 707–712.

Frankenhaeuser, M., von Wright, M. R., Collins, A., Von Wright, J., Sedvall, G., & Swahn, C.-G. (1978). Sex differences in psychoneuroendocrine reactions to examination stress. *Psychosomatic Medicine*, *40*, 334–343.

Frye, C. A., Petralia, S. M., & Rhodes, M. E. (2000). Estrous cycle and sex differences in performance on anxiety tasks coincide with increases in hippocampal progesterone and 3α, 5α-THP. *Pharmacology Biochemistry and Behavior*, *67*, 587–596.

Frye, C. A., Rhodes, M. E., Petralia, S. M., Walf, A. A., Sumida, K., & Edinger, K. L. (2006). 3α-hydroxy-5α-pregnan-20-one in the midbrain ventral tegmental area mediates social, sexual, and affective behaviors. *Neuroscience*, *138*, 1007–1014.

Geniole, S. N., Carré, J. M., & McCormick, C. M. (2011). State, not trait, neuroendocrine function predicts costly reactive aggression in men after social exclusion and inclusion. *Biological Psychology*, *87*, 137–145.

Goodyer, I. M., Tamplin, A., Herbert, J., & Altham, P. M. E. (2000). Recent life events, cortisol, dehydroepiandrosterone and the onset of major depression in high-risk adolescents. *The British Journal of Psychiatry*, *177*, 499–504.

Halligan, S. L., Herbert, J., Goodyer, I., & Murray, L. (2007). Disturbances in morning cortisol secretion in association with maternal postnatal depression predict subsequent depressive symptomatology in adolescents. *Biological Psychiatry*, *62*, 40–46.

Harris, T. O., Borsanyi, S., Messari, S., Stanford, K., Brown, G. W., Cleary, S. E., & Herbert, J. (2000). Morning cortisol as a risk factor for subsequent major depressive disorder in adult women. *The British Journal of Psychiatry*, *177*, 505–510.

Heinrichs, M., Baumgartner, T., Kirschbaum, C., & Ehlert, U. (2003). Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biological Psychiatry*, *54*, 1389–1398.

House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science*, *241*, 540–545.

Huber, T. J., Issa, K., Schik, G., & Wolf, O. T. (2006). The cortisol awakening response is blunted in psychotherapy inpatients suffering from depression. *Psychoneuroendocrinology*, *31*, 900–904.

Josephs, R. A., Telch, M. J., Hixon, J. G., Evans, J. J., Lee, H., Knopik, V. S., & Beevers, C. G. (2012). Genetic and hormonal sensitivity to threat: Testing a serotonin transporter genotype x testosterone interaction. *Psychoneuroendocrinology*, *37*, 752–761.

Kawachi, I., Colditz, G. A., Ascherio, A., Rimm, E. B., Giovannucci, E., Stampfer, M. J., & Willett, W. C. (1996). A prospective study of social networks in relation to total mortality and cardiovascular disease in men in the USA. *Journal of Epidemiology and Community Health*, *50*, 245–251.

Kessler, R. C., & McLeod, J. D. (1985). *Social support and mental health in community samples*. (S. Cohen & L. Syme, Eds.). San Diego, CA: Academic Press.

Kiecolt-Glaser, J. K., Fisher, L. D., Ogrocki, P., Stout, J. C., Speicher, C. E., & Glaser, R. (1987). Marital quality, marital disruption, and immune function. *Psychosomatic Medicine*, *49*, 13–34.

Kiecolt-Glaser, J. K., Ricker, D., George, J., Messick, G., Speicher, C. E., Garner, W., & Glaser, R. (1984). Urinary cortisol levels, cellular immunocompetency, and loneliness in psychiatric inpatients. *Psychosomatic Medicine*, *46*, 15–23.

Kirschbaum, C., Klauer, T., Filipp, S.-H., & Hellhammer, D. H. (1995). Sex-specific effects of social support on cortisol and subjective responses to acute psychological stress. *Psychosomatic Medicine*, *57*, 23–31.

Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The "Trier Social Stress Test": A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*, 76–81.

Koolhaas, J. M., Bartolomucci, A., Buwalda, B. D., De Boer, S. F., Flügge, G., Korte, S. M., & Richter-Levin, G. (2011). Stress revisited: A critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews, 35*(5), 1291–1301.

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. *Psychoneuroendocrinology*, *29*, 83–98.

Lancaster, J. B. (1986). Primate social behavior and ostracism. *Ethology and Sociobiology*, *7*, 215–225.

Leary, M. R. (1990). Responses to social exclusion: Social anxiety, jealousy, loneliness, depression, and low self-esteem. *Journal of Social and Clinical Psychology*, *9*, 221–229.

Leary, M. R., Tambor, E. S., Terdal, S. K., & Downs, D. L. (1995). Self-esteem as an interpersonal monitor: The sociometer hypothesis. *Journal of Personality and Social Psychology*, *68*, 518.

Leserman, J., Petitto, J. M., Golden, R. N., Gaynes, B. N., Gu, H., Perkins, D. O., & Evans, D. L. (2000). Impact of stressful life events, depression, social support, coping, and cortisol on progression to AIDS. *American Journal of Psychiatry*, *157*, 1221–1228.

Maner, J. K., DeWall, C. N., Baumeister, R. F., & Schaller, M. (2007). Does social exclusion motivate interpersonal reconnection? Resolving the "porcupine problem." *Journal of Personality and Social Psychology*, *92*, 42.

Maner, J. K., Miller, S. L., Schmidt, N. B., & Eckel, L. A. (2010). The endocrinology of exclusion rejection elicits motivationally tuned changes in progesterone. *Psychological Science*, *21*, 581–588.

Mannie, Z., Harmer, C., & Cowen, P. (2007). Increased waking salivary cortisol levels in young people at familial risk of depression. *American Journal of Psychiatry*, *164*, 617–621.

Mehta, P. H., Jones, A. C., & Josephs, R. A. (2008). The social endocrinology of dominance: Basal testosterone predicts cortisol changes and behavior following victory and defeat. *Journal of Personality and Social Psychology*, *94*, 1078.

Mehta, P. H., & Josephs, R. A. (2010). Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone hypothesis. *Hormones and Behavior*, *58*, 898–906.

Miller, G. E., Kemeny, M. E., Taylor, S. E., Cole, S. W., & Visscher, B. R. (1997). Social relationships and immune processes in HIV seropositive gay and bisexual men. *Annals of Behavioral Medicine*, *19*, 139–151.

Molden, D. C., Lucas, G. M., Gardner, W. L., Dean, K., & Knowles, M. L. (2009). Motivations for prevention or promotion following social exclusion: Being rejected versus being ignored. *Journal of Personality and Social Psychology*, *96*, 415.

Nemeroff, C. B., & Vale, W. W. (2005). The neurobiology of depression: Inroads to treatment and new drug discovery. *Journal of Clinical Psychiatry*, *66*, 5.

Nolen-Hoeksema, S., Larson, J., & Grayson, C. (1999). Explaining the gender difference in depressive symptoms. *Journal of Personality and Social Psychology*, 77, 1061.

Over, H., & Carpenter, M. (2009). Priming third-party ostracism increases affiliative imitation in children. *Developmental Science*, *12*, F1–F8.

Pacak, K. (2000). Stressor-specific activation of the hypothalamic-pituitary adrenocortical axis. *Physiological Research*, *49*, S11–S18.

Peterson, C. K., Gravens, L. C., & Harmon-Jones, E. (2011). Asymmetric frontal cortical activity and negative affective responses to ostracism. *Social Cognitive and Affective Neuroscience*, *6*, 277–285.

Peterson, C. K., & Harmon-Jones, E. (2012). Anger and testosterone: Evidence that situationally-induced anger relates to situationally-induced testosterone. *Emotion*, *12*, 899–902.

Plotsky, P. M., Owens, M. J., & Nemeroff, C. B. (1998). Psychoneuroendocrinology of depression: Hypothalamic-pituitary-adrenal axis. *Psychiatric Clinics of North America*, *21*, 293–307.

Pressman, S. D., Cohen, S., Miller, G. E., Barkin, A., Rabin, B. S., & Treanor, J. J. (2005). Loneliness, social network size, and immune response to influenza vaccination in college freshmen. *Health Psychology*, *24*, 297.

Pruessner, J. C., Wolf, O. T., Hellhammer, D. H., Buske-Kirschbaum, A., Von Auer, K., Jobst, S., & Kirschbaum, C. (1997). Free cortisol levels after awakening: A reliable biological marker for the assessment of adrenocortical activity. *Life Sciences*, *61*, 2539–2549.

Robbins, A. M., & Robbins, M. M. (2005). Fitness consequences of dispersal decisions for male mountain gorillas (Gorilla beringei beringei). *Behavioral Ecology and Sociobiology*, *58*, 295–309.

Roelofs, K., Bakvis, P., Hermans, E. J., van Pelt, J., & van Honk, J. (2007). The effects of social stress and cortisol responses on the preconscious selective attention to social threat. *Biological Psychology*, *75*, 1–7.

Roelofs, K., Elzinga, B. M., & Rotteveel, M. (2005). The effects of stress-induced cortisol responses on approach–avoidance behavior. *Psychoneuroendocrinology*, *30*, 665–677.

Roelofs, K., van Peer, J., Berretty, E., Jong, P. de, Spinhoven, P., & Elzinga, B. M. (2009). Hypothalamus–pituitary–adrenal axis hyperresponsiveness is associated with increased social avoidance behavior in social phobia. *Biological Psychiatry*, *65*, 336–343.

Rose, A. J., & Rudolph, K. D. (2006). A review of sex differences in peer relationship processes: Potential trade-offs for the emotional and behavioral development of girls and boys. *Psychological Bulletin*, *132*, 98.

Sapolsky, R. M. (1990). Adrenocortical function, social rank, and personality among wild baboons. *Biological Psychiatry*, *28*, 862–878.

Sapolsky, R. M. (1994). *Why zebras don't get ulcers*. New York: W.H. Freeman.

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrine Reviews*, *21*, 55–89.

Schultheiss, O. C., Dargel, A., & Rohde, W. (2003). Implicit motives and gonadal steroid hormones: Effects of menstrual cycle phase, oral contraceptive use, and relationship status. *Hormones and Behavior*, *43*, 293–301.

Sorkin, D., Rook, K. S., & Lu, J. L. (2002). Loneliness, lack of emotional support, lack of companionship, and the likelihood of having a heart condition in an elderly sample. *Annals of Behavioral Medicine*, *24*, 290–298.

Steptoe, A., Owen, N., Kunz-Ebrecht, S. R., & Brydon, L. (2004). Loneliness and neuroendocrine, cardiovascular, and inflammatory stress responses in middle-aged men and women. *Psychoneuroendocrinology*, *29*, 593–611.

Stroud, L. R., Salovey, P., & Epel, E. S. (2002). Sex differences in stress responses: Social rejection versus achievement stress. *Biological Psychiatry*, *52*, 318–327.

Stroud, L. R., Tanofsky-Kraff, M., Wilfley, D. E., & Salovey, P. (2000). The Yale Interpersonal Stressor (YIPS): Affective, physiological, and behavioral responses to a novel interpersonal rejection paradigm. *Annals of Behavioral Medicine*, *22*, 204–213.

Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, *103*, 193.

Thase, M. E., Jindal, R., & Howland, R. H. (2002). *Biological aspects of depression*. (I. Gotlib & C. Hammen, Eds.). New York: Guilford Press.

Torgrud, L. J., Walker, J. R., Murray, L., Cox, B. J., Chartier, M., & Kjernisted, K. D. (2004). Deficits in perceived social support associated with generalized social phobia. *Cognitive Behaviour Therapy*, *33*, 87–96.

Twenge, J. M., Catanese, K. R., & Baumeister, R. F. (2002). Social exclusion causes self-defeating behavior. *Journal of Personality and Social Psychology*, *83*, 606.

Van Honk, J., Tuiten, A., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., & Verbaten, R. (1998). Baseline salivary cortisol levels and preconscious selective attention for threat: A Pilot Study. *Psychoneuroendocrinology*, *23*, 741–747.

Van Honk, J., Tuiten, A., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., & Verbaten, R. (2000). Conscious and preconscious selective attention to social threat: Different neuroendocrine response patterns. *Psychoneuroendocrinology*, *25*, 577–591.

Warburton, W. A., Williams, K. D., & Cairns, D. R. (2006). When ostracism leads to aggression: The moderating effects of control deprivation. *Journal of Experimental Social Psychology*, *42*, 213–220.

Weik, U., Maroof, P., Zöller, C., & Deinzer, R. (2010). Pre-experience of social exclusion suppresses cortisol response to psychosocial stress in women but not in men. *Hormones and Behavior*, *58*, 891–897.

Wilkinson, R. G., & Marmot, M. G. (2003). *Social determinants of health: The solid facts*. Copenhagen: World Health Organization.

Williams, K. D. (2002). *Ostracism: The power of silence*. New York: Guilford Press.
Williams, K. D., Cheung, C. K., & Choi, W. (2000). Cyberostracism: Effects of being ignored over the Internet. *Journal of Personality and Social Psychology*, *79*, 748.
Williams, K. D., & Nida, S. A. (2011). Ostracism consequences and coping. *Current Directions in Psychological Science*, *20*, 71–75.
Williams, K. D., & Sommer, K. L. (1997). Social ostracism by coworkers: Does rejection lead to loafing or compensation? *Personality and Social Psychology Bulletin*, *23*, 693–706.
Wirth, M. M., & Schultheiss, O. C. (2006). Effects of affiliation arousal (hope of closeness) and affiliation stress (fear of rejection) on progesterone and cortisol. *Hormones and Behavior*, *50*, 786–795.
Zadro, L. (2004). *Ostracism: Empirical studies inspired by real-world experiences of silence and exclusion* (Unpublished doctoral dissertation). University of New South Wales, Sydney.
Zwolinski, J. (2012). Psychological and Neuroendocrine Reactivity to Ostracism. *Aggressive Behavior*. 38, 108-125.