Investigating Sex Specific Difference in Empathy: The Interaction Between Oxytocin and Estrogen

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INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Abstract

Oxytocin (OT) is a neurobiological molecule which facilitates fundamental aspects of social cognition and human interaction. As a highly conserved neuropeptide, OT may have been important in the development of modern behavior in social situations. The importance of OT in human development may be because the neuropeptide regulates neural mechanisms in the "social brain" which controls for behavior and thoughts related to moral intuitions and how people perceive and communicate with others, or social cognition. Empathy is the emotional component involved with social cognitive processes such as social recognition and emotional state matching, and is greatly affected by oxytocin. Differences in how individuals display empathy, especially between sexes, have been well identified in previous literature but the role that oxytocin plays in these differences is still unclear. To understand differences in empathetic behavior, mice models have been used. However, the previous research lacks investigation of empathy in female mouse models due to changes in hormones throughout their estrous cycle. Previous research indicates that estrogen hormones may affect the role of oxytocin in females causing differences in some social behaviors, such as empathy. Utilizing female mice models to assess changes in social behavior throughout the estrous cycle may be beneficial to clarify sex specific differences of oxytocin. The interaction between sexually dimorphic hormones and oxytocin are the most likely cause for differences in sex specific empathetic behavior.

Keywords: Empathy, estrous cycle, social cognitive deficits, sex-specific differences
Humans have an inherent desire to understand one another and socialize. Socio-emotional processing, the processes related to our ability to cooperate, share ideas, and develop morality, are what many believe separate us from other species. Proper functioning of culture and civilization derive from our advancing socio-emotional abilities (Adolphs, 2009). Empathy is one process that has been shown to be a motivating socio-emotional process in understanding and cooperating with others (de Waal, 2008). Given that the definition of empathy varies throughout the literature, I define empathy as the capacity to comprehend and respond to the behavior of agents by inferring their mental states (Zaki, 2014). Empathy is an affective and innate feeling that allows us to understand the emotional state of others. Emotion recognition, emotional perspective taking and affective responsiveness are three subcomponents of empathy (Derntl et al. 2008). Situational factors and individual motives affect how we integrate empathy subcomponents to understand and interact with the world around us (Zaki, 2014).

While empathetic processes have been investigated on a behavioral level, the specific neural processes are largely unknown. Mapping brain activity clarifies how behavior is initiated, maintained, and adapted in different situations. Clear images of brain activation involved with empathy processes allows researchers to construct paradigms and studies to measure how our understanding of one another affects social behavior. Before brain imaging, self-report measures on empathy constituted most behavioral research on empathy. Recently, research on the neural processes related to empathy have helped to define the types of behavior and structures involved with shared experiences (Bernhardt & Singer, 2012). Shared experience’s fall under the empathy
category of state-matching meaning when another person is in pain, we feel that persons pain. Researchers have found that when we experience another person’s pain, the same brain parts light up in us as the person experiencing pain (Bernhardt & Singer, 2012). The brain imaging results suggest that shared networks of brain activation mean shared feelings and therefore empathy for individuals through similar brain activity. However, the affective state of empathy is broader than shared experience and there is still a need in the literature to measure brain activation of many cognitive and behavioral empathy constructs. To expand our understanding of empathy behavior, we must expand how we measure empathy in brain responses. I predict that

Research on determining the aspects of key socioemotional processes in the social brain is growing, completing an interactive map within the brain linking social behavior to neural mechanisms. Brain structures and pathways related to social cognition are referred to as the Social Brain (Adolphs, 2009). The social brain hypothesis theorizes the brain expands in accordance with the complexity of our society so humans can care and help one another more. The fact that the human brain is growing indicates that we have more brain space contributed to processing how to behave and thrive in social situations. Increasing brain volume and capacity could therefore relate to the increasing desire for societies to come together and help one another. More than ever before, countries are putting together humanitarian efforts for the betterment of all lives. Language is transitioning to be more inclusive and respectful of all societies members. Fear and biases towards others remain a prevalent problem to societal growth, but humanity seems evolutionarily motivated and driven to overcome those problems with the development of social brain pathways.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Structures and networks in the social brain are highly related to processes in empathy (Yamasue, Kuwabara, Kawakubo, & Kasai, 2009). Functional magnetic resonance imaging reveal the three subcomponents of empathy have specific pathways in the brain within the social brain and empathy networks (Morelli, Rameson, & Lieberman, 2012). Empathy and interpersonal interaction constructs show correlate activation during functional imaging in the posterior inferior frontal gyrus, anterior medial prefrontal cortex, anterior insula, and fusiform gyrus (Morelli, Rameson, & Lieberman, 2012; Yamasue et al., 2009). Strength of social connections, prosocial behavior, and relationship bonding seems correlated to neural activation in the septal area of the brain (Morelli, Rameson, & Lieberman, 2012). Distinct pathways for socio-emotional processing indicate that the comprehensive neural model of social behaviors is large and intricate and that communicative signals in the brain may be difficult to target through only one form of neuromodulation. While this may prove troublesome in a clinical aspect, understanding neural mechanisms in empathy processes still provide guidance in how to best facilitate and investigate social behavior.

Determining the neural mechanisms and molecular functioning of empathetic processes will clarify the role of empathy in facilitating social behavior. Importantly, deficits in empathetic processes cause impaired social cognition leading to difficulties in one’s ability to facilitate human interaction and social behaviors. The causes of social deficits are likely related to decreased brain functioning in some way (McClure, York, & Montague, 2004). Few treatments exist for those with social behavioral deficits. Clarifying the neural basis of empathy in the brain may help psychologists and clinicians improve social behaviors of individuals through improvements in brain activity and cognitive thought-processes.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Psychiatric diseases, such as autism and schizophrenia, may benefit from findings related to the improvement or clarification of neural functioning of empathetic processes. For example, working knowledge of the molecular biology and neural structures involved in reward pathways has led to steady progress in treatment options and advancements for those experiencing addiction (McClure, York, & Montague, 2004). Experimental mouse models helped researchers identify pathways and brain structures to analyze in humans with brain imaging technology. By better understanding the brain, researchers then developed treatments focused on modulating brain activity that have helped those with Parkinson’s Disease, depression, addiction, and other cognitive deficits. The goal of this research is therefore to understand the brain mechanisms underlying social behaviors via a mouse model so the research can be translated to humans. A stronger understanding of the mechanisms involved in social behavior will serve as targets for treatments and therapies for those who have decreased empathy capabilities.

One specific disorder where individuals show decreased social and empathy capabilities is Autism Spectrum Disorder (ASD). In addition, socio-emotional sex-specific differences appear to be exaggerated in clinical disorders involving social skill deficits (Yamasue et al., 2009). Males are diagnosed with ASD disproportionately more than females. Research indicates one cause of increased ASD in males and decreased empathetic abilities is that males also have less grey matter volume compared to females (Baron-Cohen et al., 2005; Yamasue, Abe, Motomu, Haruyasu, Rogers, Aoki, Kato, & Kasai, 2008). Grey matter is the part of the brain that is made up of neurons and is important in brain signaling and pathway activation. A loss of gray matter in the brain means a decreased ability for the brain to process social behaviors and may cause impairments for those with ASD.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Varying differences in psychometric abilities between genders have also been found, suggesting male brains and female brains seem to be wired differently to accommodate competing evolutionary behaviors (Baron-Cohen et al., 2005). Sex-specific differences in rates of ASD and empathy behaviors suggest that different neural processes may occur given one’s biological sex. Differences in brain functioning based on sex have been investigated and suggest that this may be a prevalent mechanism yet to be understood in empathy processes. In the next section, I discuss some of the research on sex-specific differences in empathy behavior and brain activity that have been found.

**Sex-Specific Differences in Brain Activity and Empathy**

Interestingly, sex-specific differences in structural activation and social processing have been discovered (Yamasue et al., 2009). On a behavioral level, sex-specific differences in empathy seem obvious. Women are more likely to cooperate in groups while males in general have better systemizing skills (thinking and making decisions based on ordered rules) (Brandstrom, Richter, & Przybeck, 2001). Female children are better at recognizing facial expressions, and show greater activation in the brain in response to humor (Leibenluft, Gobbini, Harrison, Haxby, & Mothe, 2004; Platek, Keenan, & Mohamed, 2005; Yamasue et al., 2008).

X-linked expression of gonadal hormones in fetal development appear to regulate neural development phenotype differences between the sexes (Yamasue et al., 2008). Examples of sex-differences of neuroanatomy affecting behavior include, sex-linked neural differences moderating mental illness probabilities, and over-abundance of testosterone exposure and androgen receptors in-utero leads to decreased social functioning, especially eye-contact (Baron-Cohen, Knickmeyer, & Belmonte, 2005; Yamasue et al., 2008). Genetic basis and sex-
differences in socio-emotional processing therefore may be related to sex-linked neurobiological differences.

Furthermore, females may be exposed to conditions that may impair social functioning. However, protective factors in females seem to decrease chances of poor social functioning. For instance, male prairie voles with neonatally altered oxytocin receptors (OTR), show drastic differences in social behavior and child rearing duties compared to non-altered male prairie voles while female prairie with neonatally altered OTR show no difference in behavior compared to non-altered female prairie voles (Bales et al., 2007).

Protective factors are therefore likely regulating oxytocin and empathy processes in social behavior given their strong importance in female evolution and survival in society. The unknown female protective factors and believed sex-specific differences have led researchers to investigate the factors that differentiate female empathetic processes from those in males. A process of the brain or body that is different given an individual’s biological sex is referred to as sexually dimorphic. Sexually dimorphic phenomena occur because of differences in chromosomes and in-utero development. One common example is anatomical differences between males and females. Biological molecules and brain functioning can also be sex-specific. In the next section, I explain more on what OTR are and how they along with oxytocin may be important in sex specific empathy behavior.

**Neurohormones and Empathy**

Sexually dimorphic structural activation is believed to be caused in part by neurodevelopment differences but also sexually dimorphic biological molecules (Baron-Cohen,
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Knickmeyer, & Belmonte, 2005; Isreal, 2008; Morelli, Rameson, & Lieberman, 2012). The sexually dimorphic and evolutionarily conserved neuropeptide, oxytocin (OT), is shown to be involved with empathy, socio-emotional processes, and social bonding within the brain (Olff et al., 2013; Yamasue et al., 2009).

Oxytocin is commonly called “the love hormone” because of the hormone’s effects on positive social facilitation. OT sexual dimorphisms means the neuropeptide acts differently in males and females. Israel (2008) and colleagues have shown that an x-linked genetic mechanism involving oxytocin promoter regions length can predict altruistic behaviors and social skills. When a genetic mechanism is x-linked, men are at increased risk compared to females because they only acquire one X chromosome. Women therefore are more likely to be protected from an x-linked oxytocin problem, and therefore have less problems with oxytocin regulation and social functioning.

In broad terms though OT affects social behavior similarly in males and females. Oxytocin is a large neuropeptide produced in the central nervous system. The neuropeptide is produced in distinct neurons in the hypothalamus and secreted to the adrenal pituitary to act in peripheral systems or within the brain. Messenger RNA expression regulates available levels of OT in the brain by increasing or decreasing oxytocin receptor (OTR) quantity (Herbert, 1993; Landgraf and Neuman, 2004). OTR quantity is an important factor because OT effects are dependent on its ability to combine with its receptors which cause chemical and electrical signals that are then converted into behavior. OT binds to g-coupled receptors which activate intracellular processes to either stimulate or inhibit oxytocin mRNA expression. OTR density is high in the hypothalamic paraventricular nucleus, central amygdala, and anterior pituitary
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

(Meyer-Lindenberg, Domes, Kirsch, & Heinrichs, 2011). The high volume of OTR density means those regions are highly involved with empathy behavior. Mice with decreased quantity of oxytocin receptors (OTR) show impaired abilities to care for their offspring, respond to vocalizations of other mice, and regulate aggressive behavior (Takayanagi et al., 2005; Yamasue et al., 2009).

Varying OT levels are shown to mediate empathetic behavior (Landgraf and Neuman, 2004). Intranasal administration of OT improves social trust and emotion recognition, and reduces social anxiety and stress (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007). Emotional memory formation and maintenance is shown to be regulated by OT signaling (Neuman, 2008). Given the hormonal importance in neurotypical individuals and social abilities, OXT may have both a rewarding component and evolutionary beneficial aspect. Yet, just how OXT interactions differ in hormone interactions in males and females is largely unknown. Researchers involved with investigating and manipulating OXT pharmacologically often get wildly varied results due to the unknown interactions of OXT between male and female specific hormones (Neuman, 2008). Opposite effects of OXT as an agent of love and an agent of violence are found in the literature. Bales and Carter (2002) show increasing OXT intranasally enhances jealousy and aggressive mate guarding behavior in prairie voles. People with aggressive tendencies and enhanced OXT levels are also more likely to engage in intimate partner violence acts or thinking. Therefore, OXT processes may work in neural pathways to boost behavior for cooperation with a mate but also heighten behavior to eliminate mate threats. These opposites suggest that the neuropeptide’s evolutionary role in relationship maintenance and formation exists on a spectrum of prosocial and antisocial behavior to serve one’s best chance of survival.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

and reproduction. Increasing aggressive behavior is harmful to society and counterproductive to the efforts of improving social behavior. Ambiguity of the role of OXT in social behavior makes regulating the neuropeptide difficult and complicates research of OXT administration in social deficits treatment.

OT’s well-known hormonal role in mating and reproducing has given evidence that interactions between estrogen and estradiol may underlie some of the differences in OXT and therefore sex-specific differences of empathy (Yamasue et al., 2009). Administration of estrodial increases OTR density in the ventromedial nucleus of the hypothalamus and central amygdala (De Kloet, Voorhuis, & Elands, 1985). Estrodial therefore plays a role in OT receptor binding selectivity. The interaction of estrodial and OTR quantity is important because the results of the interaction are likely seen in the empathy behavior. Patisual (2003) and colleagues work indicate that beta oestrogen (estrogen in rodents) receptors synthesize oxytocin, strengthening the conclusion that hormones with sex-specific roles influence the role of oxytocin. Effects of estrogen and OT interacting is also evident throughout the female hormonal cycles. Again, the findings on the interaction between OT and estrogen hormones is important because both mechanisms are likely responsible for facilitating typical social and empathy behavior. Problems in one part could adversely affect the other part and deficits in social behavior may then occur.

Differential binding patterns in key social brain structures between sexes may suggest competing processes and that estrogen mediates social effects in females and not males. Female rats compared to males experience a reduction in OXTR binding in the posterior bed nucleus of the striatum terminalis (pBNST) compared to males. The pBNST is believed to be important in regulating social information processes related to recognition (Dumais et al., 2016). More
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

evidence for this hypothesis is that in female mice, OXT mRNA expression increases during proestrus/estrus and decreases in nonestrous phases (Caligioni, 2009). The increase in OXT mRNA expression downregulates available peripheral oxytocin. Behaviorally, female mice in estrous show more startle to fear-evoking stimuli, increased social responsiveness, and increased approach behavior (Dumais et al., 2016; Pisansky and Gewirtz, in press). There exists in the literature ample amount of findings of male mice and empathy behavior but more research is needed in female mice before transitioning to humans.

Many of the factors underlying sexually dimorphic hormones are studied in mouse models given that they are easier to study neuroendocrinology principles in. A mouse brain is more accessible than a humans and further mice have shorter lives. Transferring the work of oxytocin and estrogen to humans is difficult because the neural mechanisms in question are time-sensitive, and involve collecting brain tissue and cerebral spinal fluid. Therefore, more mouse models of empathy are needed to study sex-specific effects of oxytocin and estrogen in relation to social behavior.

This study begins to explore one area that studying the effects of estrogen, oxytocin, and empathy behavior may be feasible. For greater manipulation and investigation of the neurobiology of empathy, paradigms involving mouse models have been developed (Pisansky & Gewirtz, in press). Mice demonstrate social cognitive abilities which are evident in social transference and learning of fear by observing conspecifics in distress (Langford et al., 2006; Pisansky & Gewirtz, in press). In this paradigm, we examine whether levels of oxytocin throughout the estrous cycle affect fear-associated social learning behavior in mice as they observe a conspecific being shocked. We hypothesize that the varying levels of oxytocin
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

available in the brain fluctuate throughout estrous and when levels of oxytocin are highest, female mice are most responsive to the fear and pain of another mouse.

Methods

Social Conditioned Place Aversion. The paradigm, social conditioned place aversion (sCPA), investigated empathy in wildtype female mice by measuring socially learned fear. Before the task, eight female mice were assigned into unfamiliar pairs. All the mice were handled for three consecutive days, two weeks before testing. The paradigm spanned six consecutive days, with a 20min testing session in a standard conditioned place preference arena (20x25x45cm). The arenas were split into two sides separated by a plastic divider mice could cross. One side was lined with tape and had a square hole with a small cage inserted, and the other side had no tape lining or openings. The observer mouse behavior was recorded by an infrared camera placed above the arena. On the first two days of testing, an observer mouse in the unfamiliar pairs was placed in the arena to undergo habituation. The third day (pre-test), the observer mouse was placed in the arena and explored freely while the other mouse (demonstrator) in the unfamiliar pair was placed into the small cage. The first conditioning day involved trapping the observer mouse in the arena side containing the demonstrator mouse. After 5mins acclimation, the demonstrator was exposed to repeated foot shocks (1.5sec, 0.8mA scrambled current per 1min; 15 total) using the Advanced Startle software (Med Associates, Inc.). The second day of conditioning involved the same protocol, except the observer mice could explore both sides of the arena. The final day of testing (post-test) repeated the procedures for the pre-test.

Estrous Cycle Detection. Mice were briefly anesthetized with isoflurane in a glass box. As previously described in De Kloet, Voorhuis, and Elands, (1985), I inserted a pipette filled with
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

10 µL of saline into the mouse’s vaginal opening and flushed the opening 3-5 times. The specimen was deposited onto a glass side and viewed under the microscope to observe the cells present. See Appendix A for cell type classification. Estrous was detected pre-test through post-test days after the sCPA paradigm. The mice were then labeled as estrus or nonestrus depending on cells present.

Results

Footage recorded by the camera via CamApp software was analyzed using Button Box 5.0 (Behavioral Research Solutions, LLC). The video was scored and the value of the empathetic fear learning behavior (sCPA paradigm) was determined to be the change in percentage of time spent on the demonstrator side between pre- and post-test. Freezing behavior values were recorded from the two conditioning days and quantified as total immobile time. The observed values for both days were combined for each mouse.

To measure the learned fear behavior (empathy), we measured duration of time spent on demonstrator side on the pre-test day compared to the post-test day. The duration was quantified using ButtonBox5 software. The normalized difference was then calculate with the equation 

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\frac{(\text{post}-\text{pre})}{\text{pre}} \times 100.
\]

The mice were categorized per the percentage of time spent in estrous during the conditioning days. No time in estrous (nonestrus, n=2), one day in estrous (halfestrus, n=2), two days in estrous (estrus, n=4). A bivariate ANOVA was then calculated to determine the difference between the means of each group. P-value = P(F1,6 ≥ 62.032) = 2*10^{-3} (fig 1). Therefore, the results indicate that estrous phase has a significant effect of social fear learning behavior.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Discussion

We hypothesized that proestrus and estrus phases are related to higher levels of oxytocin and therefore enhanced socially learned fear behavior. Given the hypothesis is supported, then the data concludes mice in estrus during the conditioning days show increased amount of time on the non-demonstrator side on the post-test day. In addition, mice in estrus and proestrus should show higher freezing responses to demonstrator distress yet more approach behavior between shocks. Previous studies show female mice demonstrate high levels of freezing behavior indicating increased capacities for socially transmitted fear compared to males (Pisansky & Gewirtz, in press). To determine if oxytocin and estrogen interactions mediate enhanced empathy capabilities, further replication is needed. Tissue and cerebral spinal fluid collection are necessary in replication to verify either increased OXT mRNA expression or plasma. If
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

replicated findings support our hypothesis, then a correlational cause for sex-specific differences in empathetic behavior has been identified.

Targeting mechanisms in oxytocin regulation would provide researchers a more focused way to investigate the neural mechanisms of empathy components. Better knowledge of brain processes means better prediction of behavior. Improving understanding of empathy means improving empathy behavior in positive ways. Broadly, the model provided by findings and methods in this study allow for researchers to develop possible treatments for disorders which feature social deficits.

Stanovich (2012) reminds us that correlational evidence from one finding may prove to be less pivotal in behavioral processes than suggested. Before drawing conclusions of the applicability of oxytocin regulation modulation for facilitating social behavior, many barriers still need to be crossed. Again, emphasizing most neuroendocrine research in mice is difficult to investigate in humans. Female mice estrous cycles last only four days while human female’s ovarian cycles last twenty-eight days. The levels of oxytocin and estrogen may be quite different between species. Structural differences between the mouse and human brain may also lead to unsatisfactory results.

Lastly, errors in data collection may have skewed results. The cellular detection of estrous phase can be quite unclear. Labeling a mouse by only one phase presents problems and inaccuracies because a mouse may be in between phases. Predicting behavior and oxytocin levels by phase can therefore be tricky. Without knowledge of mRNA expression in the brain, and levels of oestrogen and oxytocin, we cannot confirm that oxytocin and oestrogen varied over the estrous cycle. We cannot confirm then that changes in socially learned fear behavior are correlated to varying oxytocin and oestrogen levels. Although data may suggest this correlation,
we may be drawing incorrect conclusions about the neural mechanisms involved in empathetic processes.

One useful extension to this work may be modulating OXTR and estrogen production, or the genes that promote OXTR expression. Pisansky and Gewirtz (in press) effectively show that chemogenetic modified release of OXT can affect behavior. Controlled injection of anti-sense DNA specific to oxytocin mRNA in social brain regions also showed significant correlation to empathy behavior change (Choleris et al., 2007).

Together, these results suggest that more specific manipulation of oxytocin and estrogen interactions may produce more measurable changes in social behavior in mouse models. Strengthening data and experimental measures strengthens the conclusive data. Conclusive data would be a more accurate depiction of the neural mechanisms in the brain related to empathy constructs which researchers could more easily and safely adapt to apply to humans.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

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INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN


INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN


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INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN


Appendix A

Each phase contains specific cells which can be identified under microscopy to determine phase. Proestrus contains nucleated epithelial cells, estrus contains squamous cornified epithelial cells, metestrus contains all cells but mostly leukocytes, diestrus contains leukocytes.

INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Appendix B

Lab Experience Reflection

I started working in Dr. Jonathan Gewirtz Affective Neuroscience lab as a research assistant my junior year or about 9 months before now. This was my third research experience in the psychology department so I had a lot of previous experience before joining. I inquired about the lab because I felt the focus on empathy was closely related to my own interests. I approached Dr. Gewirtz and graduate students in the lab about an opportunity to conduct an Undergraduate Research Opportunity Project or UROP. Everyone in lab I spoke to encouraged me to apply for the UROP and come in to see how the lab worked. One difference from my previous experience Dr. Gewirtz lab used mice models and not people. Before I could start in the lab, I had to get approval through IACCUC and other various organizations on campus. Getting approval was difficult because the procedures are confusing and unclear. The timeline from applying for approval and being approved was about 3 months. After I had access, I got valuable hands-on experience and developed strong research skills.

When I first joined the lab, Marc Pisansky a graduate student in the lab, showed me the various ongoing projects and how I could help. To work with the mice, I had to be very diligent and methodical with everything I did. The experiments required several steps and if one went wrong, the entire data would be skewed or unusable. There have been a few times in lab where I made mistakes. Luckily, others in the lab helped when I messed up or corrected the mistake before the data collection. When I did make mistakes, people were understanding and told me to just keep at it. Being in an environment that was hands-on and supportive, strengthened my confidence as a researcher. Before I started in the lab, I didn’t feel capable doing experiments myself.
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

Over the summer though I would sometimes spend up to 8 hours in lab running my experiments for the UROP or helping others in the lab. I also worked with a graduate student to develop new methods for estrous cycle detection which I have since taught to other lab members. The time was grueling but getting the data and getting to present my results was one of the most rewarding moments in my undergraduate career. When I had to start a new project after summer, I had to decide to either help with a graduate student project or start my own. Starting my own meant I had to be able to independently plan, set-up, run, and analyze everything. I honestly didn’t feel I should start my own project even though I wanted to. I mentioned that statement to the graduate students and they said “you should never let your fear of making mistakes or feeling incapable stop you from doing the research you want”.

For the project in this paper, I started working with another graduate student, Tatyana Matveeva. Tatyana supervised the project design, data collection, and data analysis. She has encouraged me to pursue research and helped me develop my research interests. These experiences have allowed me to work on projects related to my own interests. The insight I have gained has helped me think in ways that empathy and neuroendocrine research is applicable. For instance, if the research turned out to be significant we were going to investigate similar questions in humans. This strengthened my overall interest in continuing applying this research. The experience showed me how beneficial attending a graduate program may be. Learning my interests and being encouraged by the graduate students has made me excited about the possibility of graduate training and the possibility of a life-long career in research.

This research field has grown over the past few decades. I think in part because this research might offer answers to a lot of questions. I hope in the next few decades this research will be used in treatments for individuals with ASD, Schizophrenia, or other disorders that have
INVESTIGATING SEX SPECIFIC DIFFERENCE IN EMPATHY: THE INTERACTION BETWEEN OXYTOCIN AND ESTROGEN

a component of social behavior deficits. If nothing else, working in Dr. Gewirtz research lab has made me hopeful that psychological research will continue to benefit individuals in society.