

Spring 2008

Evidence of Empathy in Animals Across Time

Jeffrey Stephen Gavel
Georgia Southern University

Follow this and additional works at: <https://digitalcommons.georgiasouthern.edu/etd>

Recommended Citation

Gavel, Jeffrey Stephen, "Evidence of Empathy in Animals Across Time" (2008). *Electronic Theses and Dissertations*. 423.
<https://digitalcommons.georgiasouthern.edu/etd/423>

This thesis (open access) is brought to you for free and open access by the Graduate Studies, Jack N. Averitt College of at Digital Commons@Georgia Southern. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Digital Commons@Georgia Southern. For more information, please contact digitalcommons@georgiasouthern.edu.

EVIDENCE OF EMPATHY IN ANIMALS ACROSS TIME

by

JEF GAVEL

(Under the Direction of Janie Wilson)

ABSTRACT

Empathetic behaviors are characterized by a three-tiered hierarchical organization involving arousal, emotional contagion, and cognitive empathy. In the current study, we define each step in this hierarchy in order to build toward a paradigm that represents true cognitive empathy. We then examine the levels of empathy displayed by rats in previous paradigms and classify prior studies by level of arousal, emotional contagion, or cognitive empathy. Finally, we present two studies which examine the potential for empathetic display in rats.

INDEX WORDS: Empathy, Emotional Contagion, Cognitive Empathy, Rats

EVIDENCE OF EMPATHY IN ANIMALS ACROSS TIME

by

JEF GAVEL

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial
Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

2008

© 2008

Jef Gavel

All Rights Reserved

EVIDENCE OF EMPATHY IN ANIMALS ACROSS TIME

by

JEF GAVEL

Major Professor: Janie Wilson

Committee: Lawrence Locker
Rebecca Ryan

Electronic Version Approved:
May 2008

DEDICATION

This thesis is dedicated to the rats who serve as subjects in experimental settings around the world. Thank you for what we have learned. May we all empathize with your sacrifices

ACKNOWLEDGMENTS

Thanks to Janie Wilson for your insight and guidance. Thanks to my friends and family for your support and for listening to me explain the feelings of rats. Finally, thanks to Sidney Gavel for taking such good care of the rats, for your patience while I was working, and for being my biggest helper and supporter.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS.....	6
LIST OF TABLES.....	8
LIST OF FIGURES.....	9
CHAPTER	
1 INTRODUCTION.....	10
2 LEVELS OF EMPATHY.....	12
3 RODENT PARADIGMS INVOLVING EMPATHY.....	16
4 EXPERIMENT 1.....	21
5 EXPERIMENT 2.....	28
REFERENCES.....	44
APPENDICES	
A Study Groups (Independent Variables).....	50

LIST OF TABLES

	Page
Table 1: Correlations Among Dependent Variables.....	38

LIST OF FIGURES

	Page
Figure 1: Experiment 1 Results.....	24
Figure 2: Anticipated Results of Experiment 2.....	27
Figure 3: Interaction graph for prolactin.....	31
Figure 4: Grooming Occurences.....	33
Figure 5: Grooming Duration.....	34
Figure 6: Rearing Main Effect Across Conditions.....	35
Figure 7: Interaction graph for rearing.....	36

CHAPTER 1

INTRODUCTION

Empathy, from the German “Einfühlung,” was first translated into English by Titchener in 1909 (Hornblow, 1980; Preston & de Waal, 2002). Titchener’s idea of empathy was that a person could project conscious awareness into another person’s environment from observing that person’s environment. Empathy was thought to involve insight into the motivations of other people’s behaviors. At that point in the history of psychology, insight into behaviors was the primary source of measurement in research (Nisbett & Wilson, 1977; Marcel, 2003). Because the idea that people could innately understand the human mind was a common notion of the time, empathy has always been a characteristic attributed solely to humans.

The “perspective taking” necessary for empathy may only be accomplished with a broad cognitive understanding, which only humans may possibly possess. However, not all emotions involve a broad cognitive ability for understanding. Most of the earlier theories with regard to empathy ignored this fact. Until 1975, researchers focused on the depth of another’s perspective that empathy made perceivable. Some researchers thought that empathy might involve a shallow perspective like gaining an understanding of another’s mood (Greenson, 1960; Rogers, 1975), while others thought that empathy would allow more in-depth perspectives, allowing the understanding of covert behavioral motivation (Stotland, 1969).

In 1975, the first step at somewhat uniting the multitude of ideas on empathy was published by Feshbach. In his work, Feshbach addressed the distinction between cognitive empathy and empathy for state affect. Feshbach argued that both cognitive and

affective components contribute to feedback systems and that the affective component produces arousal, while the cognitive component simultaneously interprets the arousal. This view would posit that the two components are inseparable and that both are necessary for empathy. While this may indeed be true, we can examine the building blocks of empathy by looking first at arousal, then emotional contagion, and finally cognitive understanding, or what has been termed cognitive empathy.

CHAPTER 2

LEVELS OF EMPATHY

Arousal

The first layer of empathetic behavior is arousal. When we are aroused our behavior changes. For example, Guerin (1986) lead participants into a room to complete either simple or complicated tasks. A confederate in the room either paid no attention to the participant or watched the participant intently. Regardless of the confederate's behavior, having a person in the room lead to increased arousal in the participants, and this arousal influenced participants such that they made more mistakes while completing complicated tasks and fewer mistakes while completing simple tasks. Results were more pronounced when the confederate was watching intently. Therefore, arousal can be the result of simply being in a social situation (Guerin, 1986); we are influenced by the presence of others.

Note that arousal of the participant's emotion (which may or may not trigger behavior as in the above example) is not tied to the emotion of the confederate. Arousal in this case simply refers to increased sympathetic system activity in the presence of another; emotions of actor and observer need not match. This is the crucial difference between arousal and our next topic, emotional contagion.

Emotional Contagion

When arousal leads to transference of state affect, emotional contagion occurs (Preston & de Waal, 2002). For example, when we hear someone laugh, we tend to laugh more ourselves (Young & Frye, 1966). When we hear happy or sad people speak, we tend to use a corresponding tone and mood when interacting with them (Neumann &

Strack, 2000). Also, Termine and Izard (1988) report that nine-month-old infants imitated facial expressions when the experimenters demonstrated sadness, joy, or anger, and that this imitation often resulted in the infant adopting the associated mood: sadness, joy, or anger. These studies demonstrate that emotional contagion reflects a match between emotions of actor and observer.

Matching can best be illustrated in a study by Craig and Weiss (1971). In their study participants were given shocks at the same time as a confederate. The threshold at which subjects considered the shocks painful was determined. The subject and confederate were told to indicate pain intensity as shock intensity was increased. If confederates indicated that they were in pain quickly, subjects would also quickly reach threshold. If the confederate indicated that they could tolerate more intense pain, subjects would take longer to reach threshold. The threshold for responding to shock was dependant on the influence of similar social responding from others. In other words, we try to respond to stimuli the same way that other people respond.

Some researchers postulate that responding similarly to each other serves as a “social glue” encouraging social relationships, and ultimately survival. Emotional contagion is quite useful when the environment is ambiguous. In the presence of others, people will respond to the environment using behavior that is appropriate to the group. Behaviors that are typical to the group are then utilized in an ambiguous environment. To further strengthen our tendency toward emotional contagion, we find it reinforcing when others respond similarly to us (Clayton, 1978). Further, when we match our own responses to those around us, we are reinforced. This social reinforcement can encourage the use of such social behaviors in future settings. When our emotional state is shaped by

prior social situations, emotional contagion is responsible. However, when understanding of those prior situations leads to understanding of an emotional state, cognitive empathy occurs.

Cognitive Empathy

Cognitive empathy involves as its most basic component arousal, and it could be argued that emotional contagion exists as well. Additionally, when arousal leads to transference of state affect (emotional contagion) because of a cognitive understanding of the situation, cognitive empathy occurs (Preston & de Waal, 2002). During cognitive empathy, observation of an arousing situation leads to an understanding that often relies on previous personal experience. Any situation that one has experienced can potentially be understood. Thus, the understanding enabled by prior experience can facilitate cognitive empathy when another creature is in the same situation

Likewise, a lack of prior experience prohibits cognitive empathy because cognitive understanding is not available. For example, rhesus monkeys are typically able to communicate and read each others' emotions through facial expressions (Miller, Banks, & Kuwahara, 1966). However, monkeys who had been isolated since birth had no social experience and therefore were incapable of reading affect through facial expressions (Miller, Caul, & Mirsky, 1967). They lacked the necessary prior experience to establish understanding of the emotions of others, so cognitive empathy could not occur.

In a telling experiment by Masserman and colleagues (1964), rhesus monkeys learned that pulling a chain would provide food and that pulling a second chain would provide twice as much food. Then, researchers paired pulling the more rewarding chain

with shock to the monkey's conspecific, a same-sex, sibling monkey. Monkeys who had prior experience with shock showed a preference for the nonshock chain. Two of these monkeys stopped pulling chains altogether for days and nearly starved themselves to withhold pain from others. Their unwillingness to inflict the shock they personally knew to be painful can be interpreted as cognitive empathy.

CHAPTER 3

RODENT PARADIGMS INVOLVING EMPATHY

In an attempt to demonstrate “altruism,” or what the authors called empathy, Rice and Gainer (1962) trained rats to press a lever to lower a distressed, squealing rat suspended from the ceiling. In the control condition, a Styrofoam block was suspended. Subjects would not press a lever to lower a Styrofoam block, but they reliably pressed the lever to lower the squealing rat. The results were interpreted as an altruistic or empathetic response to the distress of another rat. However, Lavery and Foley (1963) argued that the squealing of the suspended rat may simply have been annoying, creating arousal that the lever-pressing rat chose to stop. Hence, the same results could be interpreted as mere arousal of the lever-pressing rat; in which case, lever pressing would simply be self-serving.

As a direct follow-up to this study, Lavery and Foley (1963) trained mice to press a lever to turn off either a prerecorded squealing rat, or white noise. Rats in their study would reliably press a lever to eliminate sound in either condition. These results supported their hypothesis that the rats in the Rice and Gainer study were possibly only trying to relieve arousal. Pressing the lever could have been due to altruism, but was more likely directed at relieving personal arousal. Taken together, these studies demonstrate that early empathy research may actually have assessed arousal, and any responses likely occurred to reduce personal discomfort.

In another early attempt to create a rodent paradigm of empathy, Church (1959) trained rats by either shocking an observer rat while shocking a target rat, shocking an observer rat while not shocking a target rat, or not shocking the rat at all. Rats were

recorded while bar pressing for reinforcement, and baseline measures were taken. Then, they were recorded while another rat was being shocked in front of them. Rats that had been shocked in the presence of a target rat being shocked decreased bar presses. The rats that had been shocked without the target rat being shocked also decreased the number of times they would press the bar. However, the latter group did not decrease bar presses as much as the former group. The control group that did not receive any shock during training decreased the number of times they pressed the bar, but only slightly. The difference in how much decrease was shown in bar presses was related to the strength of the emotional association to shock. The rats that were not shocked still had a significant emotional reaction to the emotional responses of the conspecifics; therefore, these results characterize emotional contagion.

In a subsequent study by Rice (1964), researchers tried to show that observer rats would work to turn off the shock experienced by another rat. The observer rats were first trained to turn off their own shock by pressing a bar. Then the shock chamber was divided with a clear partition. The observer rat was placed in the side with the bar, while the target rat was placed in the other side. Only the target rat's side was shocked. It was thought that the observer would observe the distress in the target and act to turn off the shock; however, this did not happen. Instead the observer rats displayed fear by retreating to the furthest corner of the chamber and freezing. This fear response was displayed by trained rats as well as untrained rats. The fact that untrained rats reacted with fear when they had never been subjected to shock shows that they were merely reacting to the emotional state exhibited by the target rats. Even when the observer rats were safe on the

non-shock side of the partition, they still reacted with emotional contagion when the shock was turned on.

Although cognitive empathy might have been expected in the group that had prior experience with shock, this did not happen. Fear in this paradigm may have been too intense for the animal to do anything but freeze. Fear removes the ability to initiate a behavioral response, like bar pressing, as an indicator of stress. Therefore, a more accurate measure must be explored that might better indicate the stress of the animal. For example, a rat measure of stress could involve a hormonal measure.

Mogil (2006), showed such a trend towards the social impact of pain responding using the writhing test. In his study, mice were injected with either a low or high dose of acetic acid in the stomach. Animals that were given a low dose and paired with an animal that was given a high dose showed more writhing behaviors than when paired with an animal with an equal dose. Also, animals given a high dose and paired with an animal that was given a low dose showed less writhing behaviors than when paired with an animal with an equal dose. The results could be explained as emotional contagion, or a sharing of emotional responding to pain between the two animals.

In a similar study with mice, Raber and Devor (2002) used animals selectively bred to display either a high pain response or a low pain response. Mice bred in the low response group consistently displayed a certain number of licking responses to a surgically induced injury. Animals bred to the high response group consistently displayed significantly more responses than the low response group. The different mice were put into groups with either two high responding mice and one low responding mouse, or two low responding mice and one high responding mouse. In the group with two high

responding mice, the low responding mouse displayed a significant increase in the number of responses to pain. In the group with two low responding mice, the high responding mouse displayed a decrease in the number of responses to pain. Individual subjects did not show any change when paired with mice of a similar pain response threshold. The increase or decrease can be seen as another example of emotional contagion.

All of the rodent studies outlined here can be explained as mere arousal or emotional contagion, with the latter two studies suggesting that emotional contagion is a “sharing” of emotion between two creatures. Note that the stress or pain responses of one animal were reduced when a less affected animal was present. Conversely, the stress or pain of one animal was increased when a more affected animal was present. Therefore, we sought to examine the idea of shared stress between two animals during emotional contagion by measuring circulating prolactin, a hormone known to be released in response to stress (Gala, 1990). Specifically, Wilson (2001) has shown that prolactin levels change in response to social cues during stress, although her emphasis was on social buffering rather than emotional contagion.

In the first experiment, we tested groups of rats in pairs of same-sex litter-mates. In our primary group of interest, one rat in the pair was trained to fear a chamber previously paired with footshock, and the other animal was trained to not fear the chamber. Two animals with no footshock training tested together and two animals trained to fear the chamber tested together served as our two comparison groups. Within the shock/no shock pair, we expected the shocked rats to have lower levels of stress (as measured by prolactin) compared with the control pair in which both rats were shocked,

as an indication of social buffering (Wilson, 2001). In addition, we expected the non-shocked rats in the shock/no shock pair to have higher levels of prolactin compared with the comparison group with no shock.

CHAPTER 4
EXPERIMENT 1

Method

Subjects and Apparatus. 60 (30 males and 30 females) adult, Long-Evans Hooded rats were used in this study. Lighting was on a reversed 12:12 light:dark schedule, with the light phase beginning at 6:00 p.m. under 75 watts of white light. Temperature was maintained at 21C, and humidity at 50%. Water and rat chow were available *ad libitum*. Rats were obtained by breeding animals from Harlan Sprague Dawley Laboratories. The day of birth was considered postnatal day (PD) 0. Litters were culled to 10 pups, and they remained with dams in Plexiglas cages (45.7 cm L x 23.5 cm W x 21.0 cm H) with pine bedding until weaning. On PD 21, juveniles were weaned and pair-housed with same-sex littermates in the same type of Plexiglas cages until testing in adulthood. Of each pair, one rat was randomly chosen to be marked with blue ink to facilitate behavioral scoring. All of the testing occurred between 11:00 a.m. and 2:00 p.m. under 200 watts of red light. All animals were acquired, maintained, and tested in accordance with the *National Institutes of Health Guide for the Care and Use of Laboratory Animals*.

Apparatus

The shock chamber (Med Associated, Inc.) was made of metal on two sides with a Plexiglas front and back for viewing (25.4 cm L x 30.5 cm W x 29.2 cm H) and steel grid flooring through which 1 mA scrambled footshock was delivered.

Procedure

Between PD 90 and 100, rats were single housed in Plexiglas cages (25.4 cm L x 22.9 cm W x 21.0 cm H) with pine bedding and randomly assigned to testing conditions.

In group 1, both rats in each pair were exposed to the chamber for 10 min which was then followed with a 10 sec foot shock. After training, the rats were returned to their home cages. In group 2, the first rat was exposed to the shock chamber for 10 min followed by a 10 sec foot shock. The second rat was exposed to the chamber for 10 min but no foot shock followed. In group 3, both rats were placed one at a time into the shock chamber but neither was shocked. Training continued for 3 consecutive days, followed by 1 day of testing. On test day, no shocks were administered. Each pair of rats was put into the shock chamber together for 10 min. Within 1 min after testing ended, each rat was decapitated.

Hormonal Assays. All assays followed the methodology prepared by ALPCO for their EIA kits. The limit of detection for this kit was 0.2 ng/ml, and intra-assay variability was acceptable.

Results

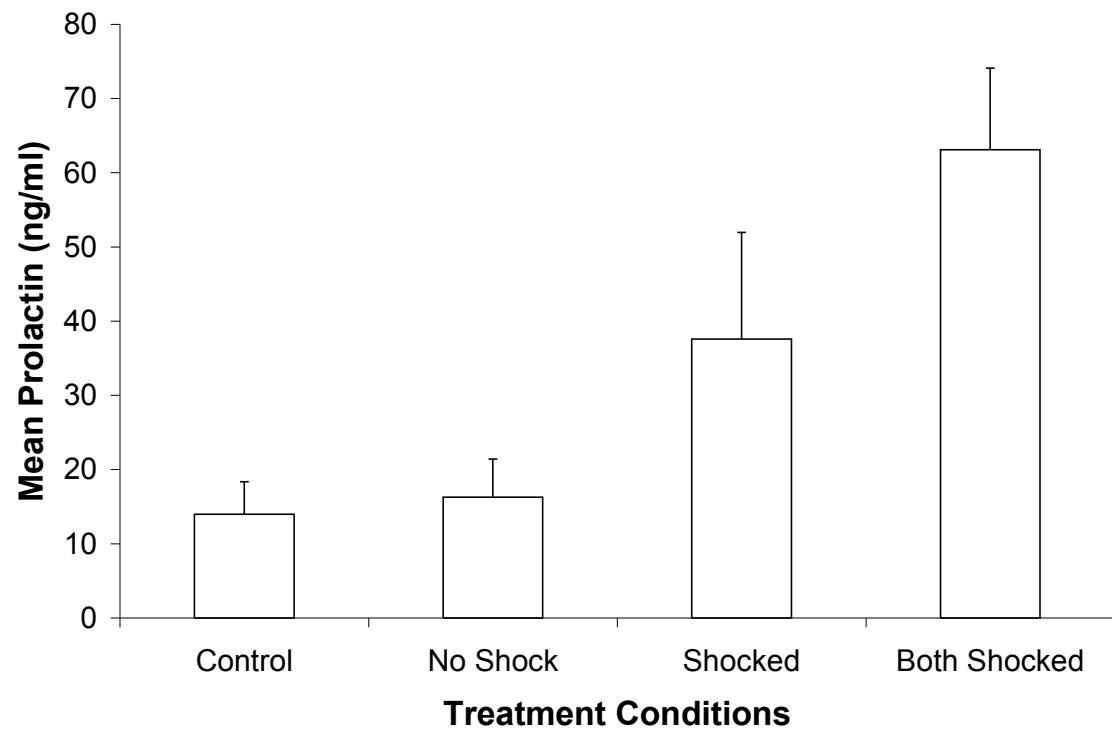
A 2 x 4 (gender x treatment condition), between-groups ANOVA was used to analyze prolactin levels. Treatment conditions affected stress levels, $F(3, 33) = 5.62, p < .01$, with an effect size of .34. When both rats were shocked, prolactin was higher ($M = 63.09, SEM = 11.00$) than nonshock controls ($M = 13.98, SEM = 4.40$) and nonshocked rats in the experimental group ($M = 16.28, SEM = 5.14$). There were no main effects of gender, and there were no interaction effects between gender and treatment condition. However, means were in the predicted direction for social buffering and emotional contagion (see Figure 1).

Discussion

The unshocked control animals had little fear of the situation. When they were in the testing apparatus together, both animals had low prolactin levels. The behaviors and prolactin levels of this group represented our definition of no fear. Conversely, when two of the animals were put together and both were shocked, both animals learned to fear the shock chamber. By both of them fearing the shock chamber and both of them displaying fear behaviors when tested, they possibly contributed to each other's high stress levels because they were both responding in the same way. The behaviors and prolactin levels of this group represented our definition of fear.

In our primary group of interest, one rat learned to fear the chamber, while the other rat learned that the chamber was safe. Because the shocked animal was displaying fear behaviors, the unshocked animal's confirmation that the situation was safe was now in question, and emotional contagion should occur. Just as when a shocked rat is with a shocked rat the stress levels are elevated (both feel unsafe), the stress of an unshocked rat

Figure 1: Experiment 1 Results



should also be elevated by the presence of a shocked rat. Based on the prolactin means of our groups, we have some evidence for sharing of emotion during emotional contagion.

However, we do not yet have a paradigm to examine cognitive empathy in rodents. In the experimental group of our first study, the response of the shocked rat was the only influence that the unshocked rat had to raise its stress. The unshocked rat saw the behaviors of the shocked rat and that behavior was the only possible source of stress. This highlighted why the difference between the unshocked experimental and control rats was not significant. When the unshocked rat was in the chamber with the shocked rat and observed the behaviors of the shocked rat, it did not understand why that rat had fear for the chamber. Because the unshocked rat had no fear, it could not understand why the other rat would. It never saw the other rat being shocked. It never had any experience witnessing any fear related event within the chamber at all. Because of this it had no reason to be empathetic.

Cognitive empathy can only occur if one rat's prior experience facilitates cognitive understanding of a conspecific's situation. In our first experiment, cognitive understanding was not facilitated in the subject rats. While the subject rats were exposed to the stress behaviors of the conspecifics, they never had any prior experience with the source of that stress, shock, and only experienced the shock chamber as a "safe" place. In order to have an empathetic response, subjects must have prior experience with the shock chamber. They also must be able to observe the conspecific being shocked.

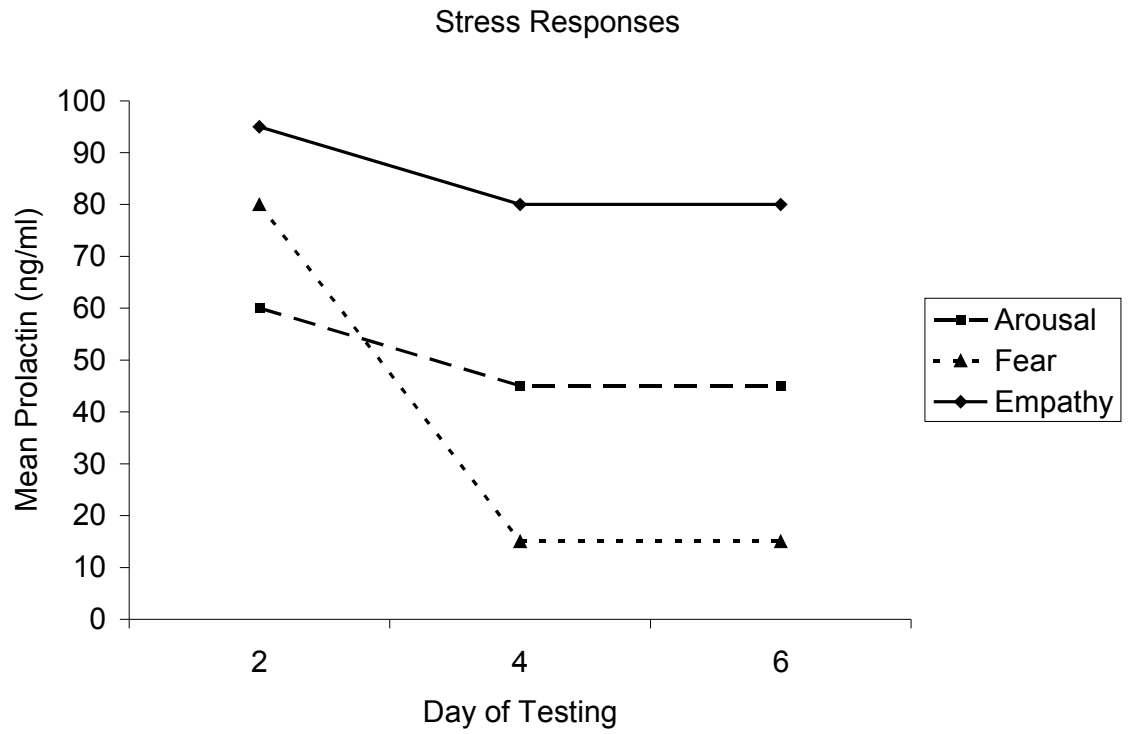
We face two major obstacles in using this paradigm: fear and emotional contagion (which includes arousal). First, if the observer has been shocked in the shock chamber before, bringing the rat back into the room and putting the rat in close proximity to the

shock chamber will elicit a fear response. Hence we will simply be measuring fear. However, if the animal is subsequently kept in a safe chamber, fear should eventually habituate; therefore we will allow habituation of fear in experiment 2 across 2, 4 and 6 days.

Second, if an observer rat is continually exposed to a conspecific who is being shocked, there will be a constant source of arousal which should cause emotional contagion. Cognitive empathy could not have an influence on this animal's stress unless the animal also has prior experience with the situation. Therefore, two groups are needed to distinguish between emotional contagion and cognitive empathy. In the emotional contagion group, observer rats will have no prior experience. In the cognitive empathy group, observer rats will have prior experience. Associations to stress brought out by prior experience, should increase the sympathetic activation in the nervous system increasing the flow of stress hormone. Thus, the cognitive empathy group should have higher sustained levels of stress hormone than the emotional contagion group.

In order to create a rat model of cognitive empathy, stress due to fear and emotional contagion must be taken into account as described above. We expect the prolactin levels of the cognitive empathy group to be greater than the levels of prolactin in the fear and emotional contagion groups. Further, this heightened prolactin should remain evident throughout the nine days of testing in experiment 2. (See Figure 2.)

Figure 2: Anticipated Results of Experiment 2



CHAPTER 5
EXPERIMENT 2

Method

Subjects and Apparatus. Seventy Seven (37 males and 40 females) juvenile Long-Evans Hooded rats were used in this study. Lighting was on a reversed 12:12 light:dark schedule, with the light phase beginning at 6:00 p.m. under 75 watts of white light. Temperature was maintained at 21°C, and humidity at 50%. Water and rat chow was available *ad libitum*. Rats were obtained by breeding animals from Harlan Sprague Dawley Laboratories. The day of birth was considered postnatal day (PD) 0. Litters were culled to 10 pups, and they remained with dams in Plexiglas cages (45.7 cm L x 23.5 cm W x 21 cm H) with pine bedding until weaning. On PD 21, juveniles were weaned and rehoused with same-sex littermates in the same type of Plexiglas cages. All animals were acquired, maintained, and tested in accordance with the *National Institutes of Health Guide for the Care and Use of Laboratory Animals*.

Apparatus

The shock chamber (Med Associated, Inc.) was made of metal on two sides with a Plexiglas front and back for viewing (25.4 cm L x 30.5 cm W x 29.2cm H) and steel grid flooring through which 1 sec of 1 mA scrambled footshock was delivered at the end of every 30s for 10 min during training and testing sessions. All training and testing occurred between 11:00 a.m. and 2:00 p.m. under 200 watts of red light.

Procedure

On PD 28 and 35, rats were assigned to one of 3 experimental conditions: an empathy condition, an arousal condition, or a fear condition. In the empathy condition, on

the training days, rats were shocked in the shock chamber on 2 consecutive days to engender a cognitive appreciation for the stressor. During subsequent testing days, they observed a conspecific being shocked in the shock chamber. This condition was considered a model for empathy due to watching another rat being shocked and cognitive understanding of the shock discomfort.

In the arousal condition, on the 2 training days, rats were exposed to the shock chamber but were not shocked. During subsequent testing days, they observed a conspecific being shocked in the shock chamber. Their responses were considered a pure measure of the emotional contagion due to the pain behaviors of the conspecific. That is, the aroused rat had no personal fear of the chamber but only heard and observed the conspecific act as though a stressor was present. This should be arousing, disturbing, or even annoying to the observing rat. In the fear condition, on the training day, rats were shocked in the shock chamber to learn that the chamber was to be feared. During subsequent testing days, they observed the empty chamber to assess a pure measure of fear to the testing room.

On all training days, rats were placed in the shock chamber; those in the empathy and fear conditions were shocked, and those in the arousal condition were not. On all testing days, rats in the 3 experimental conditions were placed in the testing room in cages containing bedding from their home cages. They were not placed in the shock chamber. Instead, their home cages were pushed up against the shock chamber, and they observed another rat in the chamber, or in the case of the fear condition, they simply observed the empty chamber that they had learned to fear.

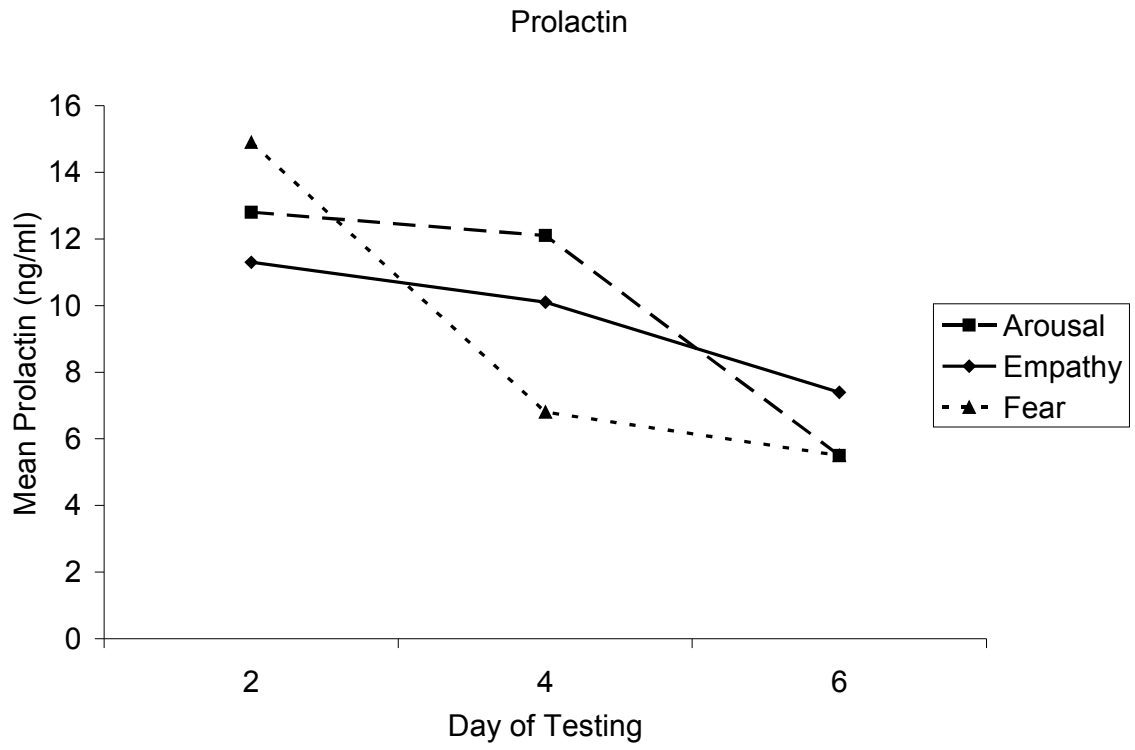
During testing, rats in the empathy and arousal conditions both observed the same shocked conspecific by placing the empathy and arousal home cages on either side of the shock chamber. This reduced the number of rats needed for the experiment and reduced the number of rats experiencing footshock. The conspecific (in the middle) received shocks as indicated above for a 10-min testing period. The entire experimental protocol extended across 2 training days and 6 testing days. One third of the animals were sacrificed on day 2, one third were sacrificed on day 4, and the final third was sacrificed on day 6 (see Appendix A).

Results

A 3 (days) x 3 (conditions) between-subjects ANOVA was used to analyze hormonal data. Testing day had an effect on stress level as indicated by prolactin (ng/ml), $F(2, 4) = 4.06, p < .05$. As time elapsed, stress levels attenuated (Mean total day 2 = 13.09, $SD = 10.50$; day 4 = 9.84, $SD = 5.30$; day 6 = 6.27, $SD = 7.30$). However, different treatment conditions did not display significant mean differences ($p > .05$). (See Figure 3 for detailed mean information.) A 3 (days) x 3 (conditions) between-subjects MANOVA was used to analyze the behavioral data, with the following dependant variables: grooming duration, grooming occurrence, rearing, ambulation duration, and ambulation occurrence. Significant effects were further analyzed using Tukey's post hoc comparisons ($p < .05$). Testing day did not affect behaviors ($ps > .05$); however, several behaviors were affected by treatment condition.

Grooming duration was significantly different across treatment conditions, $F(2, 39) = 3.79, p < .05, \eta^2 = .16$, with animals grooming more in the arousal condition ($M = 32.53, SD = 56.68, n = 16$) than the fear condition ($M = 1.27, SD = 4.92, n = 15$), and a

Figure 3: Interaction graph for prolactin



tendency toward more grooming in the empathy condition as well ($p = .068$, $M = 4.15$, $SD = 15.18$, $n = 17$). Similarly, grooming occurrences were significantly different across conditions, $F(2, 39) = 3.38$, $p < .05$, $\eta^2 = .15$, with animals in the arousal condition having more grooming occurrences ($M = .69$, $SD = .79$, $n = 16$) than those in the fear condition ($M = .07$, $SD = .26$, $n = 15$), and a tendency toward more grooming in the empathy condition ($p = .087$, $M = .24$, $SD = .56$, $n = 17$). (See Figures 4 and 5)

Rearing was also significantly different across treatment conditions, $F(2, 39) = 8.40$, $p < .01$, $\eta^2 = .30$, with rats in the fear condition rearing more times ($M = 16.47$, $SD = 8.16$, $n = 15$) than those in the empathy condition ($M = 11.53$, $SD = 4.54$, $n = 17$) and the arousal condition ($M = 9.13$, $SD = 5.73$, $n = 16$). (See Figure 6.) However, the rearing effect was qualified by an interaction across conditions on different test days, $F(2, 39) = 3.19$, $p < .05$, $\eta^2 = .25$. For rats in the empathy group, rearing did not significantly change across days of testing ($ps > .05$). Conversely, those in the arousal condition reared more on day 4 ($M = 11.71$, $SD = 6.95$, $n = 7$) than on day 6 ($M = 5.00$, $SD = 2.45$, $n = 4$). In the fear condition, rats reared more on day 6 ($M = 23.20$, $SD = 8.11$, $n = 5$) than on days 2 ($M = 11.17$, $SD = 2.93$, $n = 6$) and 4 ($M = 16.00$, $SD = 8.76$, $n = 4$). Specifically on day 6, the fear rats reared more than the empathy rats ($M = 13.80$, $SD = 5.81$, $n = 5$), who reared more than the arousal rats. (See Figure 7.)

Correlations Among Dependent Variables

Prolactin was significantly correlated with ambulation occurrence, $r(45) = .26$, $p < .05$; more prolactin was associated with more ambulation activity. Further, ambulation occurrence was negatively correlated with rearing, $r(46) = -.39$, $p < .01$. Thus, increased

Figure 4: Grooming Occurrences

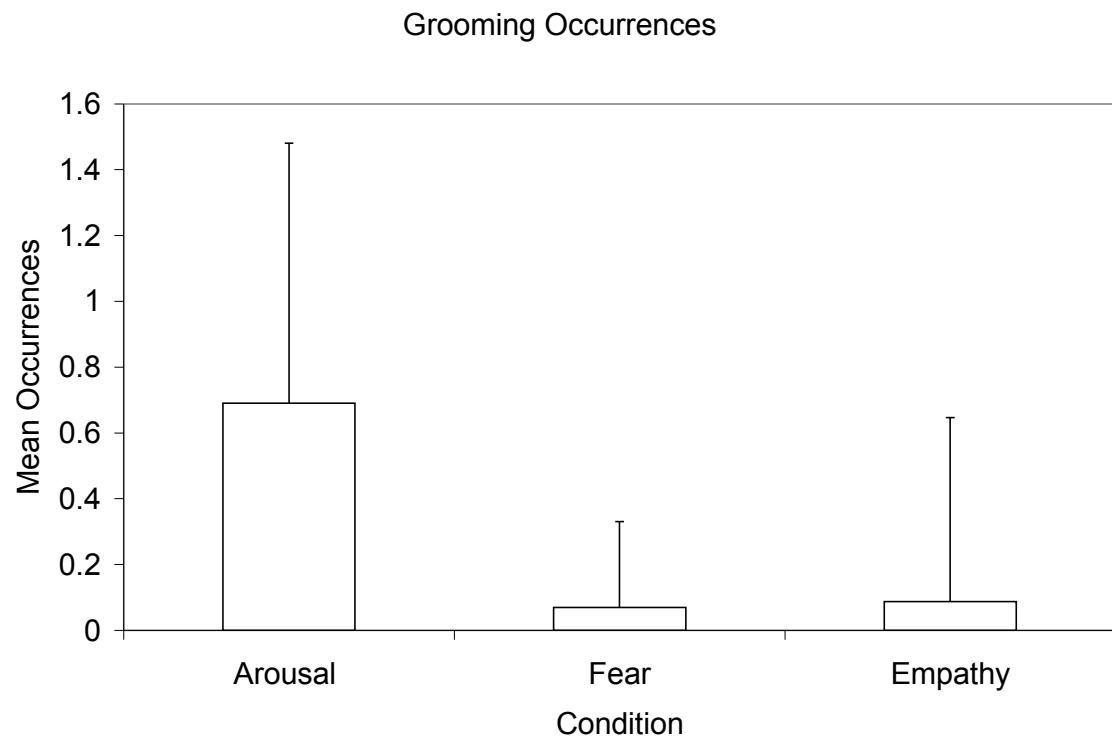


Figure 5: Grooming Duration

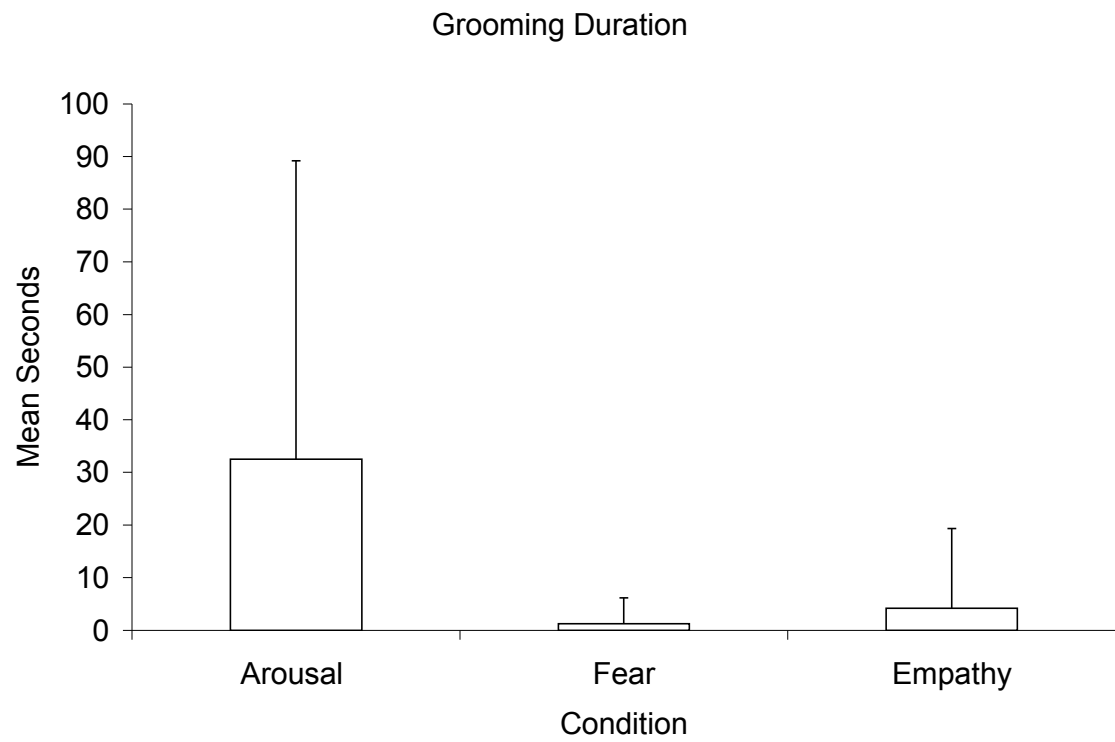


Figure 6: Rearing Main Effect Across Conditions

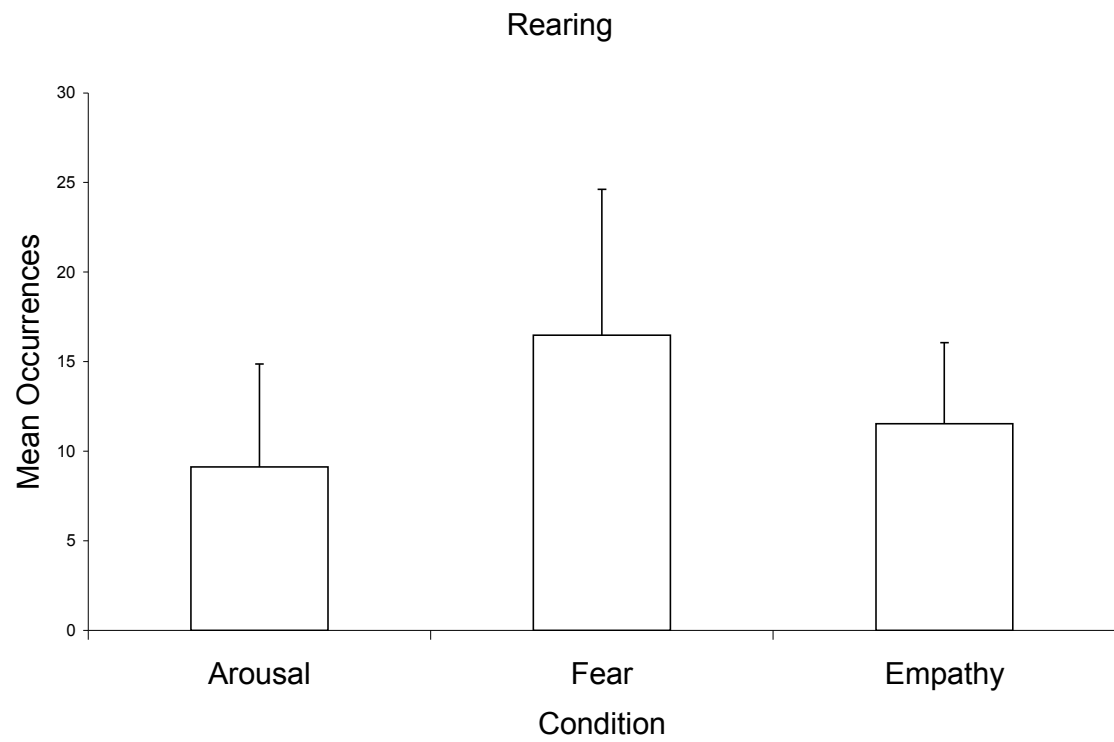
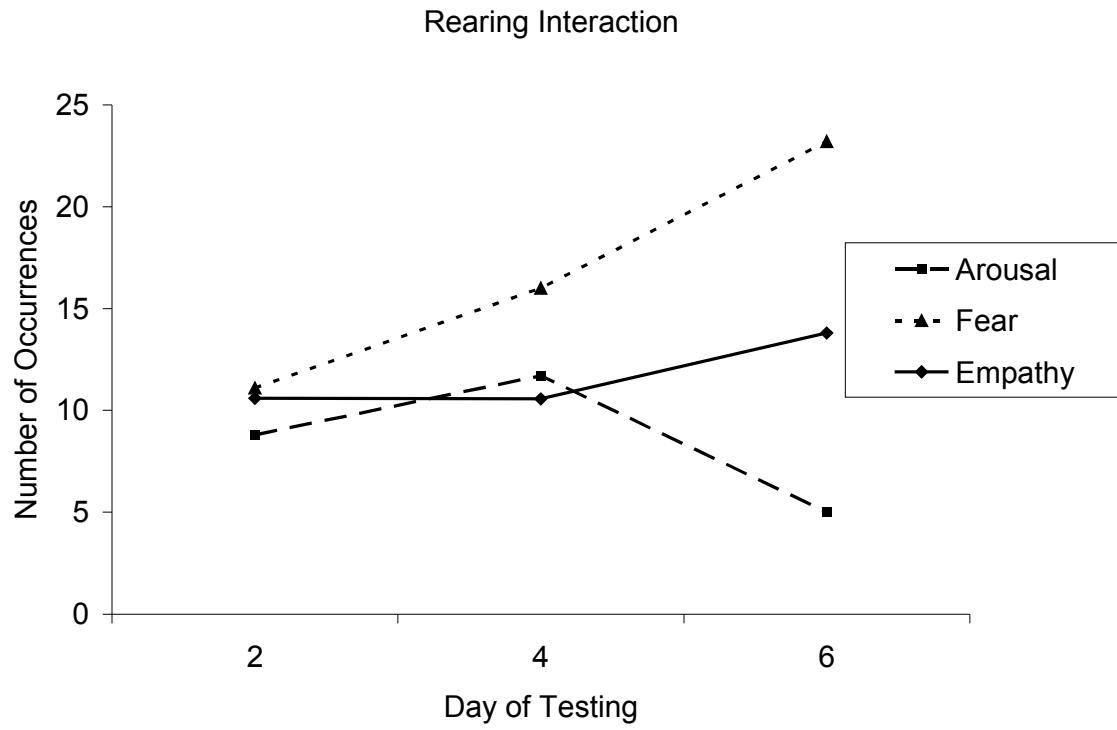


Figure 7: Interaction graph for rearing



ambulation was associated with more prolactin and more stress. In the opposite pattern, increased rearing and grooming were associated with lower stress based on negative correlations between ambulation and the measures of rearing and grooming. (See Table 1.)

Discussion

The test results show that across days there are significant differences in prolactin; however, on each individual day there were not significant differences between testing conditions. Although this is the case, the group means are very telling. On day two, the fear group has the highest stress level. The first comparison that should be made is between this group and the empathetic group. The empathetic group on day two showed a mean prolactin concentration of about 11, while 14 was the mean prolactin concentration for the fear group. Eleven and 14 are not substantially different but the fact that there is any difference is odd because the fear animals and the empathetic animals both received the same treatment. Both groups received shock during the training period and were then placed beside the shock chamber. The fear animals subsequently were not subjected to another animal being shocked and for them there were no additional stressors during test days. The empathetic animals were subjected to other animals being shocked. It seemed that the empathetic animals being subjected to shock and then exposed to another stressor would have resulted in having higher stress levels. However they had lower concentrations compared to the fear animals that received exposure to no other stressor. This indicates that prior experience with shock had a lasting effect on the fear animals that was *reduced* in the empathetic animals.

Table 1. Correlations Among Dependent Variables

	Prolactin	Ambulation Duration	Ambulation Occurrence	Rearing	Grooming Duration	Grooming Occurrence
Prolactin	r(54) = 1.00	r(45) = .07	r(45) = .26*	r(45) = -.06	r(45) = -.05	r(45) = .03
Ambulation Duration	r(45) = .07	r(46) = 1.00	r(46) = -.34**	r(46) = .52**	r(46) = -.40	r(46) = -.41**
Ambulation Occurrence	r(45) = .26*	r(46) = -.34**	r(46) = 1.00	r(46) = -.39**	r(46) = -.09	r(46) = .01
Rearing	r(45) = -.06	r(46) = .52**	r(46) = -.39**	r(46) = 1.00	r(46) = -.11	r(46) = -.14
Grooming Duration	r(45) = -.05	r(46) = -.40**	r(46) = -.09	r(46) = -.11	r(46) = 1.00	r(46) = .74**
Grooming Occurrence	r(45) = .03	r(46) = -.41**	r(46) = .01	r(46) = -.14	r(46) = .74**	r(46) = 1.00

The empathetic animal's results were not very different from the arousal animals. These animals were not subjected to shock during the training period but were subjected to another animal being shocked on the testing days. The mean concentration for the arousal animals on day two was 12, while the concentration for the empathetic animals was 11. How can the empathetic animals have the most stressors and the lowest concentrations? Is it possible that having prior experience with shock, which was very stressful for the fear animals, reduced the stressfulness of observing another animal being shocked? Also, observing another animal being shocked had a stress-producing effect on arousal animals, but the empathetic animals seem to have been protected from this effect. I predicted that there would be an additive effect in the empathetic animals, but they ended up with the lowest concentrations of all.

In the fear animals, the lasting effect of training habituated by day 4 and continued to habituate through day 6; the arousal animals' stress lowered for day 4 and then bottomed out at day 6. The empathetic animals' stress levels lowered on day 4 but never became as low as the other two groups. The empathetic animals continued to have some stress throughout the testing period, whereas the fear animals and arousal animals became habituated. The fact that the empathetic animals continued to show elevated stress on days 4 and 6 show that although fear and arousal did not combine to produce an additive effect, they did produce a longer lasting stress response.

These results do not indicate that cognitive empathy produced increased stress. What they do indicate is that there seems to be some cognitive buffer from the stress. What this means is that by having an understanding of the situation that was occurring, the empathetic animals were able to understand that they were not in immediate harm.

This understanding possibly buffered them from the additive effect that we were looking for. However, it was not a buffer from maintaining a cognitive impression of shock which produced a longer lasting stress effect. Also this understanding did not extend to either fear or arousal animals.

When the fear animals were first trained, they were taken into a room and shocked. On day 2, removing them from the colony and taking them into the room where they were shocked was stressful to them. This would explain why the fear animals had an increased stress level on day two of testing. The arousal animals who had never been subjected to shock did not understand the difference between being in the shock chamber and being in the home chamber. All they could understand was that there was a distressed animal present. The presence of that animal would indicate to them that the environment that they had been moved to is hazardous. This would explain why the arousal animals had an increased stress level on day two of testing.

The empathetic animals had been in the shock chamber, and they knew what the environment in the shock chamber entailed. For example they knew that in the shock chamber there were metal bars that they stood on and that shock was delivered through those bars. But then when they were brought back into that room on test days, they were not subjected to that apparatus (e.g., no metal bars beneath their feet). They were not placed in the shock chamber; they were in the home chamber with wood shavings on the floor and in a cage that was associated with safety. It would be very easy for them to recognize the difference between being in the shock chamber and being in the home cage. In fact, they probably learned on the training days that when they were removed from the shock chamber and replaced in the home cage that they were no longer going to be

shocked. Being back in the home chamber would have been associated with being relieved from any more shock exposure. When those animals were brought in the room on testing days and had their home cage placed beside the shock chamber, they recognized immediately that they were not in any danger because they were not placed in the shock chamber.

This understanding would have buffered their stress. It would have lowered their stress compared to what the fear animals felt while at the same time their stress levels would have been elevated slightly from being removed from the colony and being taken into that room. They did not realize that when I took them out of the colony that I would not place them in the shock chamber. Being placed in the shock chamber was still a possibility for them until I left them in their home cage. Being taken into the room would have been stressful, but then not being placed in the shock chamber would have relieved some of that stress.

It is my speculation that the reason why the empathetic animals' stress levels came out lowest of the three groups was because they initially had a stress response but that cognitive understanding buffered that stress, allowing it to abate. The arousal animals would not have had the benefit of that relief nor would they have had the fear that would have been elicited from being taken into that chamber. Thus, the arousal animals did display a pure measurement of arousal to being exposed to another animal being shocked. The fear animals showed a pure measurement of fear because they did not have the benefit of seeing that another animal was in the shock chamber.

The primary problem with this study was that the animals were kept in their home cages during testing days. If instead the animals had been placed into cages that were

duplicates of the original shock chamber, we likely would have seen much higher stress responses in the fear animals and in the empathetic animals. Shock is not salient in the home cage. The animals recognized that being in the home cage was not going to be hazardous. Animals would have been more likely to feel fear if they had been in a chamber similar to the shock chamber.

Also, if shock had been a possibility, then the empathetic animals would have thought that shock could come at any moment. Observing the other animal being shocked could have brought about an increased cognitive awareness of the salience of shock. Rather than the increase in awareness buffering their stress, recognizing that another animal is being shocked and recognizing that they are also in a position to be shocked would have increased their stress.

The arousal animals were simply buffered by the fact that their home cage was a familiar environment. If they had been placed in chambers similar to the shock chamber, their stress would have also been elevated, but it would have habituated very quickly, but not as quickly as the fear animals who soon realized that even though they were in the room where they had been shocked, they were not going to be shocked anymore. They would have gone through extinction. The arousal animals would not have gone through a quick extinction because there would have been a distressed animal in that same environment. The empathy animals would have experienced the same thing, but the fear would have been much worse because they would have already understood that shock can come any second. Having knowledge of shock and having a fear that the shock could happen at anytime would have given them more stress than the arousal and fear animals.

In a future study, we will use this exact same paradigm except that we will construct two chambers that look just like the shock chamber. This way when the animals go into these cages they will not think that they are in a safe environment. The arousal animals will be in an unknown environment, while the fear and empathetic animals will recognize that the environment is hazardous. The fear animals will habituate to this environment quickly when they realize that no more shocks are going to be administered, while the empathetic animals will not make this realization because of the presence of the other distressed animal.

References

- Augustine, J. (1996). Circuitry and functional aspects of the insular lobe in primates including humans. *Brain Research Brain Research Review*, 22, 229-294.
- Avenanti, A., Buetti, D., Galati, G., & Aglioti, S. (2005). Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain. *Nature Neuroscience*, 8, 955-960.
- Calder, A., Keane, J., Manes, F., Antoun, N., & Young, A. (2000). Impaired recognition and experience of disgust following brain injury. *Nauret Neuroscience*, 3, 1077-1108.
- Carr, L., Iacoboni, M., Dubeau, M., Mazziotta, J., & Lenzi, G. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of the National Academy of Science of the U.S.A.*, 100, 5497-5502.
- Church, R. M. (1959). Emotional reactions of rats to the pain of others. *Journal of Comparative & Physiological Psychology*, 52, 132-134.
- Clayton, D. (1978). Socially facilitated behavior. *The Quarterly Review of Biology*, 53, 373-387.
- Craig, K., & Weiss, S. (1971). Vicarious influences on pain-threshold determinations. *Journal of Personality and Social Psychology*, 19, 53-59.
- de Waal, F. B. M. (1996). *Good natured: The origins of right and wrong in humans and other animals*. Harvard University Press.
- Ferrari, P., & Gallese, V., Rizzplatti, G., & Fogassi, L. (2003). Mirror neurons responding to the observation of ingestive and communicative mouth actions in

- the monkey ventral premotor cortex. *European Journal of Neuroscience*, *17*, 1703–1714.
- Ferrari, P., & Gallese, V. (2007). Mirror neurons and intersubjectivity. In S. Braten (Ed.), **On being moved: From mirror neurons to empathy (pp. 73-88)**. Amsterdam, Netherlands: John Benjamins Publishing Company.
- Feshbach, N. (1975). Empathy in children: Some theoretical and empirical considerations. *Counseling Psychologist*, *5*, 25-30.
- Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*, 593-609.
- Gallese, V., Migone, P., & Eagle, M. (2006). Embodied simulation: Mirror neurons, neurophysiological bases of intersubjectivity, and some implications for psychoanalysis. *Psychotherapy and Human Science*, *40*, 543-580.
- Goldenberg, G., & Karnath, H. (2006). The neural basis of imitation is body part specific. *The Journal of Neuroscience*, *26*, 6282-6287.
- Greenson, R. (1960). Empathy and its vicissitudes. *International Journal of Psychoanalysis*, *41*, 418-424.
- Guerin, B. (1986). Mere presence effects in humans: A review. *Journal of Experimental and Social Psychology*, *22*, 38-77.
- Heiser, M., Iacoboni, M., Maeda, F., Marcus, J., & Mazziotta, J. (2003). The essential role of broca's area in imitation. *The European Journal of Neuroscience*, *17*, 1123-1128.
- Hornblow, A. (1980). The study of empathy. *New Zealand Psychologist*, *9*, 19-28.

- Hutchinson, W., Davis, K., Lozano, A., Tasker, R., & Dostrovsky, J. (1999). Pain-related neurons in the human cingulate cortex. *Nature Neuroscience*, *2*, 403-405.
- Iacoboni, M., Woods, R., Brass, M., Bekkering, H., Mazziotta, J., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, *286*, 2526-2528.
- Iacoboni, M., Molnar-Szakacs, I., Gallese V., Buccino, G., Mazziotta J., & Rizzolatti, G. (2005). Grasping the intentions of others with one's own mirror neuron system. *PLoS. Biology*, *3*, 79.
- Jackson, P., Meltzoff, A., & Decety, J. (2005). How do we perceive the pain of others a window into the neural processes involved in empathy. *NeuroImage*, *24*, 771-779.
- Kaplan, J., & Iacoboni, M. (2006). Getting a grip on other minds: Mirror neurons, intention understanding, and cognitive empathy. *Social Neuroscience*, *1*, 175-183.
- Kohler, E., Keysers, C., Umiltà, M., Fogassi, L., Gallese, G., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: action representation in mirror neurons. *Science*, *297*, 846-888.
- Langford, D., Crager, S., Shehzad, Z., Smith, S., Sotocinal, S., Levenstadt, J., Chanda, M., Levitin, D., & Mogil, J. (2006). Social modulation of pain as evidence for empathy in mice. *Science*, *312*, 1967-1970.
- Lavery, J. J., & P. J. Foley (1963). Altruism or arousal in the rat. *Science*, *140*, 172-173.
- Leslie, K., Johnson-Frey, S., & Grafton, S. (2003). Functional imaging of face and hand imitation: Towards a motor theory of empathy. *Neuroimage*, *23*, 601-607.
- Levine, S. (1990). The hormonal consequences of mother-infant contact. In: *Touch: The foundation of experience: Full revised and expanded proceedings of Johnson &*

Johnson Pediatric Round Table X, ed. K. E. Barnard & T. B. Brazelton.
International Universities Press, Inc.

- Marcel, A. (2003). Introspective report: Trust, self-knowledge and science. *Journal of Consciousness Studies*, *10*, 167-186.
- Miller, R., Banks, J., & Kuwahara, H. (1966). The communication of affects in monkeys: Cooperative reward conditioning. *The Journal of Genetic Psychology*, *108*, 121-134.
- Miller, R., Caul, W., & Mirsky, A. (1967). Communication of affects between feral and socially isolated monkeys. *Journal of Personality and Social Psychology*, *7*, 231-239.
- Mineka, S., & Cook, M. (1993). Mechanisms involved in the observational conditioning of fear. *Journal of Experimental Psychology: General*, *122*, 23-38.
- Morrison, I., Poliakoff, E., Gordon, L., & Downing, P. (2007). Response-specific effects of pain observation on motor behavior. *Cognition*, *104*, 407-416.
- Neumann, R., & Strack, F. (2000). "Mood contagion": The automatic transfer of mood between persons. *Journal of Personality and Social Psychology*, *79*, 211-223.
- Nisbett, R. & Wilson, T. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*, 231-259.
- Oberman, L., & Ramachandran, V. (2007). The stimulating social mind: The role of the mirror neuron system and simulation in the social and communicative deficits of autism spectrum disorders. *Psychological Bulletin*, *133*, 310-327.
- Preston, S., & DeWaal, F., (2002). Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences*, *25*, 1-20.

- Raber, P., & Devor, M. (2002). Social variables affect phenotype in the neuroma model of neuropathic pain. *Pain, 97*, 139-150.
- Rice, G. E. Jr. (1964). Aiding behavior vs. fear in the albino rat. *Psychological Record, 14*, 165-170.
- Rice, G., & Gainer, P. (1962). Altruism in the albino rat. *Journal of Comparative & Physiological Psychology, 55*, 123-125.
- Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research, 3*, 131-141.
- Rizzolatti, G., & Arbib, M. (1998). Language within our grasp. *Trends in Neuroscience, 21*, 188-194.
- Rogers, C. (1975). Empathic: An unappreciated way of being. *Counseling Psychologist, 5*, 2-10.
- Saarela, M., Helsinki, Y., Williams, A., Schurmann, M., Kalso, E., & Hari, R. (2007). The compassionate brain: Humans detect intensity of pain from another's face. *Cerebral Cortex, 17*, 230-237.
- Salvatore, G., Dimaggio, G., & Lysaker, P. (2007). An intersubjective perspective on negative symptoms of schizophrenia: Implications of simulation theory. *Cognitive Neuropsychiatry, 12*, 144-164.
- Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R., & Frith, C. (2004). Empathy for pain involves affective but not sensory components of pain. *Science, 303*, 1157-1162.
- Skipper, J., Nusbaum, H., Small, S. (2005). Listening to talking faces: Motor cortical activation during speech perception. *Neuroimage, 25*, 76-89.

Stotland, E. (1969). Exploratory investigations of empathy. In L. Berkowitz (Ed.), **Advances in experimental social psychology (pp. 271-314)**. New York: Academic.

Termine, N., & Izard, C. (1988). Infants' response to their mothers' expressions of joy and sadness. *Developmental Psychology, 24*, 223–229.

Young, R., & Frye, M. (1966). Some are laughing; some are not—why? *Psychological Reports, 18*, 747–752.

Appendix A: Study Groups (Independent Variables)

Training Day:

Empathy Rat
Shocked

Arousal Rat
No Shock

Fear Rat
Shocked

Testing Days: 1-6

Empathy Rat	Conspecific	Arousal Rat
No Shock	Shocked	No Shock
All 3 in testing room together.		

Empty chamber	Empty chamber	Fear Rat
		No Shock

One third of experimental rats will be sacrificed on Day 2, one third on Day 4, and one third on Day 6.

Independent Variable #1: Experimental Group (3 levels): Empathy, Arousal, & Fear

Independent Variable #2: Time (3 levels): Day 2, 4, & 6