

2012

# Measures of Social Cognition in the Laboratory and Real World: Towards Temporal Dynamics of Implicit Other-Regard

Danielle Tucci  
*Scripps College*

---

## Recommended Citation

Tucci, Danielle, "Measures of Social Cognition in the Laboratory and Real World: Towards Temporal Dynamics of Implicit Other-Regard" (2012). *Scripps Senior Theses*. Paper 47.  
[http://scholarship.claremont.edu/scripps\\_theses/47](http://scholarship.claremont.edu/scripps_theses/47)

This Open Access Senior Thesis is brought to you for free and open access by the Scripps Student Scholarship at Scholarship @ Claremont. It has been accepted for inclusion in Scripps Senior Theses by an authorized administrator of Scholarship @ Claremont. For more information, please contact [scholarship@cuc.claremont.edu](mailto:scholarship@cuc.claremont.edu).

**MEASURES OF SOCIAL COGNITION IN THE LABORATORY AND REAL WORLD:  
TOWARDS TEMPORAL DYNAMICS OF IMPLICIT OTHER-REGARD**

by

**DANIELLE TUCCI**

**SUBMITTED TO SCRIPPS COLLEGE IN PARTIAL FULFILLMENT  
OF THE DEGREE OF BACHELOR OF ARTS**

**PROFESSOR SPEZIO  
PROFESSOR REED**

**December 9, 2011**

## Abstract

Social cognition is a fundamental aspect of human experience that enables us to have relationships with and understanding of other people. Social relationships have been shown to mitigate cognitive decline in old age and benefit cognitive functioning, and the social interaction on which these relationships rely requires an extensive network of cognitive processes, and by extension neural systems, that have not, as of yet, been widely studied in older adults. Nor has the function of these systems been tied to social relationships in the real world. Here, I will compare self-reports of real-world quality and extent of social networks with behavioral and neural measures of other-regard in the laboratory. It is hoped that by so doing we will be able to link social neuroscientific measures in the laboratory with persons' perceptions of the quality and extent of their social relationships. In this study, other-regard in older adults was operationalized with a reaction-time measure in an implicit turn-taking task, neural measures were provided by dense array EEG, and all participants also completed self-report measures of empathy subscales and of the quality and extent of their social networks. I found that measures of empathic personal distress decreased with increased other-regard ( $r = -0.36$ ,  $p = 0.01$ ,  $R^2 = -6.464$ ,  $\beta = 0.47$ ), while increased quality and extent of social networks associated marginally with increased other-regard ( $r = 0.20$ ,  $p = 0.11$ ,  $R^2 = -6.216$ ,  $\beta = 0.39$ ). Neural analyses are ongoing and are expected to show differential activation consistent with cognitive processes such as theory of mind, empathy, joint attention, and executive control.

### Acknowledgements

I would like to thank Professor Michael Spezio for his continual guidance and inspiration for this thesis project. His patience and encouragement helped me as I designed and implemented the experiment, as well as when I was writing the thesis paper. I would also like to thank Dean Pospisil '12, Christina Boardman '12, Zoe Ravich '12, and Irina Rabkina '14 for their assistance and support as I ran participants in the Scripps College dense array EEG Laboratory.

I am grateful for the Scripps College Interdisciplinary Johnson Fellowship and the Psi Chi Summer Research Grant, which provided me the opportunity to begin work on my thesis over the summer of 2011. These awards allowed extra time and funds for the research portion of the project, for which I am very thankful. I would also like to acknowledge the National Science Foundation for providing the dense array EEG equipment to Scripps College which I was able to work with. My research experience with this cutting edge technology has helped prepare me for future work in graduate school and beyond.

I would also like to thank my family and friends, especially those in InterVarsity Christian Fellowship, for their endless support, encouragement, and love.

## Table of Contents

List of Figures .....	4
Introduction.....	5
Social Networks and Cognition in Older Adults.....	6
Effects of Aging on Neural Processing and Cognition.....	7
Cognitive Aspects of Social Functioning.....	8
Theory of Mind.....	9
Empathy and Social Cognition.....	10
Attention Switching and Executive Functioning.....	14
Joint Attention & Joint Action.....	17
Implicit Turn Taking.....	19
Social Coordination and Co-representation.....	21
Current Research.....	22
Methods.....	26
Participants.....	26
Materials.....	26
Procedure.....	26
Data Analysis.....	27
Results.....	27
Self-Report.....	28
Behavioral.....	28
Neural.....	30
Discussion.....	30
Limitations and Directions for Future Research.....	34
References.....	46
Appendix A: Interpersonal Reactivity Index.....	53
Appendix B: Lubben Social Network Scale.....	54
Appendix C: EPrime Experimental Design.....	55

## List of Figures

Figure 1. Individual and Paired Conditions.....	37
Figure 2. Comparison of Gender and Social Network Size.....	38
Figure 3. Comparison of Gender and Empathic Concern.....	39
Figure 4. Comparison of Age and Personal Distress.....	40
Figure 5. Comparison of Group RT Difference to Stimulus Condition .....	41
Figure 6. Comparison of Statistically Significant RT Differences to Stimulus Condition.....	42
Figure 7. Comparison of Age to RT Difference.....	43
Figure 8. Comparison of Age to Congruent RTs.....	44
Figure 9. Comparison of Age to Incongruent RTs.....	44
Figure 10. Comparison of RT Difference and Personal Distress.....	45
Figure 11. Comparison of RT Difference and Social Network Size.....	45

## Introduction

Social cognition is the process of understanding others by representing and experiencing other's mental states, which is critical for social development and cognitive functioning (Lieberman, 2007; Gow, Pattie, Whiteman, Whalley, & Deary, 2007). While much of our understanding on the topic has been based on research in young adults and children, there has been little investigation into the psychological and neural underpinnings of social cognition in older adults. Evidence suggests that increased social involvement in older adults facilitates healthy aging and well-being into old age. With nearly 1 in 4 Americans classified as a senior citizen in the year 2010, it is imperative to ascertain which cognitive and neural processes might contribute to increased social relationship quality and extent in older adults (U.S. Census, 2010). Conceivably, older adults may differ in subtle ways from younger adults in the ways in which their neural systems facilitate social relationships. As social interaction involves many different cognitive processes, such as theory of mind, empathy, joint attention, and executive control, it stands to reason that having a greater social network would increasingly recruit and shape these processes and their neural systems. By having more social interactions, therefore, older adults could potentially prevent cognitive decline due to aging as well as certain age-specific disorders such as dementia and Alzheimer's disease. This study investigates whether social cognition and other-regard measured in the laboratory correlate with self-report indices of social cognition such as empathic concern and real-live social network extent. This study also looks at which neural networks are involved in other-regard in older adults and whether these correspond at all to individual differences in self-reported social network quality and extent.

*Social Networks and Cognition in Older Adults*

As people live increasingly longer lives due to improving medicine and health practices, researchers are interested in the wellbeing of older adults and what factors influence people's cognitive, emotional and social outcomes. Successful aging has been shown to be positively influenced by one's social network and social support, as friends, family and marital ties can increase one's psychological well-being (Gow et al., 2007). According to the World Health Organization, prevention of social isolation is necessary for good health since loneliness, social isolation and stressful social ties can contribute to higher disability, poorer recovery from illness and even early death (World Health Organization, 2002). Supportive social ties, on the other hand, have been shown to enhance physical and mental health among older adults, as social support can act as a buffer against stressful life events and provide mental stimulation necessary for dealing with other people (Cohen & Willis, 1985; Zunzunegui, Alvarado, Del Ser & Otero, 2003). In a review of social support and physiological processes, Uchino et al. (1996) states that social support has beneficial effects such that the net effect may be to biologically age the individual at a slower rate. This has important implications for the wellbeing and quality of life in older adults. Not only does social support provide emotional, cognitive and physical stability, but it satisfies the fundamental human need to belong (Baumeister & Leary, 1995). This would lead to greater life satisfaction and desire to interact with more people, thus propagating the cognitive and social benefits. Similarly, the National Institutes of Health Cognitive and Emotional Health Project has stated that emotional support and social networks are potential protective factors against cognitive decline (Hendrie, Albert, Butters, Gao, Knopman, Launer et al., 2006). Cognitive decline is thus not an inevitable consequence of growing older, but can be mitigated by positive social networks. This is consistent with the "Use it or lose it" hypothesis, in

which the mental stimulation needed to interact with others delays cognitive impairments and protects the brain against pathological processes by creating better cognitive strategies and potentially increasing neural growth and synaptic density (Zunzunegui et al., 2003). Social network quality and extent thus positively influences mental health in old age. There is also a considerable body of evidence which show that an intellectually stimulating lifestyle predicts better maintenance of cognitive functioning in old age and is associated with a decreased risk of developing Alzheimer's disease, dementia and other age-related neurological disorders (Hertzog, Kramer, Wilson, & Lindenberger, 2009). Since social interaction necessitates many different cognitive abilities and is mentally stimulating, it is probable that having more social interaction would lead to better cognitive outcomes later in life. Therefore, social cognition can contribute to improved quality of life, decreased risk of neurological disorders and successful aging.

#### *Effects of Aging on Neural Processing and Cognition*

With these effects of social cognition in mind, it is important to assess what causes cognitive decline in older adults, how they can be mitigated and what other neural changes occur in old age. Aging is known to associate with decreased neurocognitive functioning due to microanatomical changes in the brain such as decreased synaptic density, neuronal density and neuronal size, as well as decreases in gray matter in the prefrontal cortex (Aine, 2011). Furthermore, it has been suggested that cognitive processes supported by the prefrontal lobe are among the first to decline with increasing age (Tisserand & Jolles, 2003). Therefore, it is reasonable to suggest that people with better social networks and social support would have better cognitive processing and subsequent well-being than those who are socially isolated, because they would utilize cognitive functioning which is served by the prefrontal cortex, such as ToM, joint attention and attention switching, in their social interactions on a regular basis.

Interestingly, it has also been shown that older adults have different neural patterns for certain cognitions than younger adults, such as memory, even if these cognitive functions have not declined over the years. A study by Cabeza et al. (2002) showed that older adults had more bilateral prefrontal activation for memory retrieval whereas young adults showed only right prefrontal activation. These findings are consistent with the frontal deficit hypothesis mentioned above and suggest that the older adults were compensating for their decreased gray matter in the prefrontal cortex by recruiting additional brain regions in order to maintain the same level of cognitive ability as in earlier life. This research further shows that in normal aging adults there are changes in brain structure and connectivity that can affect neurocognitive processes even if there is no decline in cognitive functioning. In this way, it is important to investigate the neural networks of social cognition in older adults to see whether any changes in brain structure due to aging have affected their neurocognitive social processing and whether there are more efficient neural networks in people who have more social interaction.

### *Cognitive Aspects of Social Functioning*

In order to better understand the positive effects of social interaction, one must first understand the cognitive processes that underlie social cognition. To effectively interact with others and understand their behavior, one must have insight into what others believe, think and feel, and understand how these mental states relate to their behavior (Lieberman, 2007). This requires understanding oneself in relation to others, perspective taking, and understanding others as similar but distinct from oneself. While there are many cognitive processes involved in understanding others' mental states, the three major processes discussed here are theory of mind (ToM), empathy and joint attention. ToM relates to the ability to represent another's psychological state by understanding that other people have minds with thoughts and feelings

similar to oneself. Empathy and joint attention, meanwhile, relate to experiencing another's mental state through shared perceptual ground (joint attention) and shared emotional responses (empathy). These shared mental states give rise to an understanding of what the other person is going through and increased social liking and bonding (Decety & Lamm, 2006). Interestingly, there have been few studies which show the correlation between these social cognitive processes and social network extent. It would seem self-evident that if people had smoother social interaction due to these cognitive processes, they would also have more social contact as a result. This study aims to rectify this lack of empirical evidence by showing the behavioral and neural metrics of such cognitive processes and if they relate to real-world indices of social cognition such as social network extent. For now, however, it is important to look at these cognitive processes more in-depth, in order to further understand their significance for social cognition.

### *Theory of Mind*

Theory of mind (ToM) is the ability to recognize another as similar to oneself but also distinct. It is a cornerstone for social cognition which allows us to take the perspective of another and understand other's mental states such as beliefs, intentions, emotions and thoughts, in order to predict their behavior. ToM has also been called "mind-reading" or mentalizing, as this understanding of other's minds is key to successful social interaction (Frith & Frith, 1999). It typically develops in humans by the age of four and is involved in a greater awareness of the intentions and perspectives of others (Lieberman, 2007). While ToM has traditionally been studied in developmental psychology, it has many implications for social psychology and neuroscience. As shown in a study by Humphreys & Bedford (2011), neurological patients with impairments in ToM showed decreased other-regard in a "social Simon" task. This meant that people with little or no ToM did not take into account the presence of another person during a

social turn-taking task. Such a finding thus strengthens the relationship between ToM and social cognition. Since ToM includes the representation of another person and their mental state, it necessitates numerous cognitive abilities and is critical for effective social interaction. ToM has been shown to utilize several brain regions such as the medial prefrontal cortex (MPFC), superior temporal sulcus (STS) and temporal-parietal junction (TPJ). Of these, the MPFC plays a predominant role in the understanding of self and another's mind (Mason & Macrae, 2008). Likewise, it has been implicated in integrating the representations of another person and of that person's mental state (Wang et al., 2011). The anterior paracingulate cortex (aPCC) has also been implicated in understanding social intention, along with the left TPJ (Ciaramidaro, Adenzato, Enrici, Erkd, Pia, Bara, Walter, 2007). This is interesting because the aPCC is connected to the anterior cingulate cortex (ACC) which is involved in attentional switching, executive functioning and self-regulation, processes that would also be necessary for social functioning (Lieberman, 2007). These studies illustrate that ToM is important for social cognition by helping us understand the motives, intentions, thoughts and beliefs of another person through perspective taking and mental representation. Without ToM, we would be impaired in our ability to distinguish others from the self and would have difficulties imagining what another person might be thinking or experiencing.

### *Empathy and Social Cognition*

One form of ToM is empathy, which relies on intuition and is a central part of social cognition. Empathy is the social ability to accurately recognize and share the feelings of others, without confusion between one's own feelings and another's. In this way, it is an experiential ToM which encompasses a number of different cognitive functions. It is further defined within psychological and neuroscientific circles by its three main components: an affective response to

another person's emotional state, perspective taking and emotion regulation (Decety & Jackson, 2006). From an evolutionary perspective, affective sharing between self and others stems from our unconscious automatic mimicry of facial expressions and behavior. Such mimicry triggers similar expressions on one's own face which results in similar emotional perception and feeling, allowing for greater understanding of what the other person is experiencing and leading to prosocial behaviors such as altruism (Preston & de Waal, 2002). From a social psychological perspective this unconscious mimicry leads to smoother social interactions and increased liking, which serves to foster relationships with others. Therefore, people with higher levels of dispositional empathy tend to show this "chameleon" effect to a greater extent, and would propagate this trait since they would have a greater social network who could then help them in their times of need (Decety & Lamm, 2006). This automatic processing of other people's emotional states leads to simulation of their mental state, which can create an empathic response towards the other person given the right circumstances. Cognitive processes such as contextual appraisal, beliefs about the other person and motivation can block empathic responses, for instance if one feels that the other person deserves to be in pain, even if the person is able to simulate the other's mental state. In this way, simply imitating others and representing their psychological state is not enough to always evoke empathy. Despite this, however, mimicry and simulation are necessary building blocks for understanding what other people are experiencing and, given the right context and motivation, to share their emotions (Vignemont & Singer, 2006).

The ability to experience another's emotions via empathy has also been explored with cognitive neuroscience. In neuroimaging studies, it has been shown that when people view others in physical or emotional pain, they also feel a similar sense of pain through neural systems that produce such states in themselves (Jackson et al., 2005). These shared neural circuits suggest that

people are able to simulate neurally what another person is feeling and that similar networks are used to represent one's own and others' affective pain. However, the neural network involved in pain processing is activated more extensively and includes other brain regions when imagining oneself in pain, which is consistent with the pattern of activity detected in the first-hand experience of pain. In this way, people who empathize with others simulate and feel another's pain but not to the same extent as if they were in physical or emotional pain themselves (Decety & Lamm, 2006). This experience of another's affect thus illustrates the second key part of empathy, which is the ability to distinguish others from oneself. Empathy thus does not involve a complete Self-Other merging, but allows for understanding what others are experiencing, while distinct from oneself. A complete overlapping between self and other representation leads to empathic overarousal or personal distress, which is a self-focused, aversive response to another's emotional state (Decety & Jackson, 2006). Perspective taking is therefore fundamental to social interaction since it allows people to shift between the other and self perspectives and leads to adaptive social behavior. Prosocial behavior such as altruism has been shown to be influenced to a large extent by the ability of a person to empathize and take the perspective of another without confusion with one's own perspective (Baston et al., 1991).

Lastly, empathy involves emotion regulation and self agency. When one adopts the perspective of another, one needs to be able to disentangle oneself from the experiences of others in order to prevent emotional distress or anxiety, which is an aversive reaction to the emotions felt by another. Emotion regulation thus necessitates the ability to maintain a sense of whose feelings belong to whom and the intensity of the emotion felt. Furthermore, research has shown that emotion regulation positively relates to feelings of concern for the other person, suggesting that people who are able to regulate their emotions are more likely to experience empathy and act

in morally desirable ways towards other people (Eisenberg et al., 1994; Eisenberg et al., 2004). In this way, the ability to cope with the distress of another person, which relies on emotion regulation capabilities, affects the experience of empathy. If a person is not able to regulate their own emotions, they are more likely to experience emotional distress rather than empathy in response to another's experiences (Decety & Jackson, 2004). Likewise, one's sense of self agency and self-awareness is crucial for understanding and acting on one's empathic response towards another. Being aware of one's own emotions and feelings enables reflection on these emotions and whether one will choose to help the other person. Emotion reappraisal requires the use of cognitive and emotional synthesis, as a person becomes cognizant of why they feel a certain way and if the emotion is sufficient to elicit a behavioral response, such as in altruism (Decety & Jackson, 2004). Thus, empathy necessitates emotional regulation and self agency so that people are not overwhelmed by their emotions, but are able to understand their emotions and the emotions of others, and to act positively in response to them.

Even when a person exhibits these major components of empathy, such as perspective taking and emotion regulation, they do not always have an empathic response towards others. Another major influence on the experience of empathy is the context of the social situation and relationship between the two people interacting. For instance, when people are in a competitive situation they will tend to show counterempathetic responses, so that they will experience a positive affect when a competitor loses and negative affect when he or she wins. Even though the person may be able to take on the perspective of the competitor and simulate the other person's emotions, their attitudes towards the competitor interfere with their experience of empathy towards the other person (Lansetta & English, 1989). Interestingly, gender has also been shown to play a role in empathic responses towards others. When a fair, liked player was in pain both

men and women experienced empathy for that person, but when an unfair and disliked player was in pain, men showed an increase in activation of reward-centers in the brain that correlated with their desire for revenge. In this way, the men's motivation for revenge overcame their empathic concern when they believed the other person deserved to be in pain (Singer et al., 2006). As these examples suggest, the attitudes one holds for the other person who is in emotional or physical pain affects whether one will experience empathy towards that person.

The essential aspect of empathy is therefore the ability to recognize another person as like oneself while maintaining a clear separation between self and other, which is accomplished by effective perspective taking, emotional regulation and self agency. Our ability to distinguish ourselves from others prevents emotional distress and anxiety from interfering with our capacity to empathize and act in a prosocial way towards others. Furthermore, by mimicking other's facial expressions and having similar neural processing as another person through simulation, we are able to experience the same feelings as another and understand their perspective more fully. While social context and gender can play a role in the modulation of empathic responses, ultimately it is our attitudes towards another person and ability to take their perspective that affects whether we will share the same emotion as them. This affective response to another's emotional state therefore allows us to have a better understanding of what others are thinking, feeling and doing. In this way, empathy facilitates more fluid social interaction due to shared emotions and perspective taking, and can lead to positive social behavior (Singer & Lamm, 2009).

#### *Attention Switching and Executive Functioning*

Another necessary aspect of social cognition is attention switching and executive functioning, such as cognitive control and conflict monitoring. Attention switching is important

for social interaction, since it allows a person to be aware of one's own goals and thoughts while attending to another person and their mental state. By shifting attention between the self and other, one is able to have a greater ToM and more fluid social interaction (Young, Dodell-Feder, & Saxe, 2010). If a person were continually focused on the self, they would not be able to understand the other person's perspective, and if the person was only focused on the other, they would ignore their own goals and needs, potentially to their own detriment. It is therefore beneficial to have an executive control of attention so that people can focus on salient aspects of the social interaction, whether it is understanding the other person's perspective or reflecting on their own desires and needs. The relationship between attention switching and ToM has been shown in a study by Scholz et al. (2009), in which neighboring regions in the TPJ were differentially activated for these cognitive processes. While the brain regions involved are distinct for each cognitive process, it shows that the TPJ subserves both ToM and attention switching, and suggests that increased ability in one area could benefit the other. Furthermore, the control of attention involves the coordinated activity of both prefrontal and parietal brain regions (Tamber-Rosenau, Esterman, Chiu & Yantis, 2011). These areas, such as the MPFC, mediate the transition of attention from one object to another in order to achieve behavioral goals, and are also seen to be involved in ToM. Thus, the link between attention switching and social cognition can be made through both neuroimaging evidence and psychological reasoning.

Conflict monitoring and cognitive control are other important aspects of social cognition that are generally only measured in executive functioning tasks. Conflict monitoring allows people to maintain social rules and norms by monitoring their behavior in social interactions and gauging the responses of other people to their own actions. This ability to monitor one's own actions according to a set of rules has been seen in paradigms such as the Stoop task. In this

experiment, participants are required to name the color of ink of a set of words, which are usually color names themselves. Participants must inhibit their automatic response of simply reading the words and instead attend to the ink color and keep the rules of the experiment in working memory. Through such as task, participants show their ability to error check and self-evaluate their own performance. These skills are also necessary in social settings, as evidenced by continuous self-appraisals of one's behavior to facilitate social interaction. Furthermore, the Stroop task has been shown to elicit activation in the ACC and dorsolateral prefrontal cortex (Swick, & Jovanovic, 2002). These brain regions are also activated in social cognition such as ToM and suggest that similar neural networks are used for both these cognitive processes. Likewise, cognitive control is important for social cognition because it helps people to achieve their goals in social interactions by maintaining selective attention to a particular object or person, even in the face of other distractions. Paradigms such as a dichotic listening task utilize this cognitive ability, as people are asked to attend to auditory stimuli from only one ear and disregard competing auditory stimuli from the other ear. It has been found that the ACC and medial frontal gyrus are implicated in selective attention, and that the localization in the ACC overlapped with areas known for cognitive processing, rather than emotional processing (Hugdahl et al., 2009). These neural networks are also seen in joint attention, which is a subset of attentional processes that is specific to social cognition, and provide evidence for similar processes in both social and cognitive domains. Thus cognitive control and selective attention affect how well a person is able to attend to another person, with other internal and external distractions present, and can influence social interaction.

All this evidence suggests that executive functioning plays a role in social cognition and interaction. While most studies do not compare the two domains explicitly, it is possible to draw

conclusions from these empirical findings and apply them to social cognition. With overlapping neural networks involved in attention switching, cognitive control, conflict monitoring, ToM and joint attention (to be discussed shortly) such as the ACC, MPFC and TPJ, it seems likely that these executive cognitive processes are involved in social cognition and can positively influence one's interactions with others.

### *Joint Attention & Joint Action*

The last major cognitive processes behind social cognition discussed here is joint attention and joint action. To date, the majority of experiments in the fields of cognitive psychology and cognitive neuroscience have only measured humans as they perform solitary tasks. However, in recent years researchers have begun to explore the neural and behavioral differences between dyadic and single humans, particularly in social paradigms involving joint attention and joint action. Joint attention is the sharing of common perceptual ground between two people, usually by following another's eye gaze. This allows people to focus on the same thing as they are having a conversation, for example, and so links the two minds to the same visual environment. By perceiving what others perceive, we are able to better understand what they are thinking and relate to them better. All social interaction requires the effective deployment of joint attention even when such action is "simple" conversation and even in the absence of pointing and other gestures . This phenomenon was illustrated in the study by Richardson et al. (2007) in which participants were physically separate but had a two-way conversation via headset about a visual display. Eye tracking recordings showed that participants coupled their eye movements based on what aspect of the picture they were talking about, even though the other person was not able to gesture or make eye contact with them. Participants also looked at the same thing more frequently if they were given similar information about the visual

display than if they were given different information. This study suggests that joint attention is context dependent and occurs even when there is no visual contact between people, enabling them to share a common ground and have a better understanding of one another.

Interestingly, joint attention has been shown to activate similar brain regions as in ToM, such as the superior temporal sulcus (STS). This implicates that social representation occurs in the STS, as it is more responsive to eye shifts that convey social meaning such as where people's interests lie (Pelphrey et al., 2003). As this social information helps us understand one another's intentions and state of mind better, joint attention is a necessary marker for fluid social interaction (Frischen et al., 2007). It is not only important for social development and vocabulary learning, but allows people to convey emotions, beliefs and desires, especially through gaze cueing and eye contact. Furthermore, joint attention has been shown to influence the extent and quality of social networks across the life span, which leads to greater social interaction and social cognition (Dunbar, 2008). By having similar perceptual experiences as another person, we are able to better understand their intentions and goals, which thus facilitate social interaction and theory of mind.

Joint attention is also necessary for coordinating with another in joint goal directed behavior, or joint action. Joint action is defined as any form of social interaction where two or more individuals coordinate their actions in space and time to bring about a change in the environment (Sebanz et al., 2006). Therefore it is not enough to simply imitate what the other person is doing; rather, people need to understand the joint goal and the other's actions in order to plan and execute their own actions in relation to what they anticipate the other will do. By having a mental representation of the other's action, they are able to incorporate it into their own action planning and thus coordinate their own behavior accordingly. For instance, in an fMRI

study by Newman-Norlund et al. (2007), participants in a virtual bar lifting task were asked to balance a ball on top of a bar where each participant lifted only one side of the bar. Each participant had to anticipate the other's actions in order to respond with their own actions so that the goal could be achieved. Furthermore, participants in this joint action condition were found to mentally simulate the actions of the other and incorporate it into representations of their own actions through the activation of the human mirror neuron system, which has been shown to be involved in representations of the self and others. In this way, it seems as though task sharing and shared cooperative activities such as joint action necessitate the incorporation of others' actions as one's own in order to better facilitate joint goal directed behavior.

### *Implicit Turn Taking*

Social cognition has also been seen in a number of paradigms which involve both joint attention and joint action. In dyadic Go-NoGo experiments, each participant is required to respond only to a certain stimulus which is the opposite of the other participant. Therefore, the Go trial for one participant is the NoGo trial for the other participant, resulting in an implicit turn taking task. Thus, dyadic Go-NoGo experiments involve response inhibition, turn taking, shared perceptual ground and self-monitoring.

These studies have shown that people respond differently when with another person compared to when they are alone. For instance, when the specific stimuli participants are to respond to is on the same side of the screen as another participant or pointing at the other participant, they take longer in responding because they think it is the other participant's turn. Known as the Simon effect, it refers to the finding that participant's performance is slower when the spatial relationship between stimulus and response is incongruent. Interestingly, this effect was not seen when participants were alone because they were the only one responding to stimuli

(Sebanz et al., 2006; Sebanz et al., 2007; Tsai et al., 2006). In this experiment, two participants were asked to attend to visual stimuli on a computer screen and to respond to a picture of a hand pointing either to the left or to the right. Participants sat next to each other, so it looked as if the hand was pointing at either the participant sitting to the right or the participant sitting on the left. The participants were assigned to respond to the color of the ring on the hand quickly as possible by pressing a button on a response box pad that corresponded to their assigned ring color. In this way, the Go trial for one participant was a NoGo trial for the other participant and resulted in an implicit turn taking task. When participants responded to their colored ring when the hand pointed at the other participant, they showed the “social Simon effect” since the stimulus was incongruent to their spatial position. Likewise, when the hand pointed at themselves it was considered a congruent condition, and participants responded quicker because they believed it was their own turn. The neural mechanisms involved in single versus dyadic conditions differed greatly in this task, especially on Go trials. Sebanz et al. (2006) and Tsai et al. (2006) both found an increased P3 and N2 event related potentials (ERPs) during incompatible Go trials. This is explained by the fact that the participants were both anticipating the other’s actions and planning their own response, whereas in a single condition the participant would not be anticipating another’s actions. Since similar neural mechanisms are involved in monitoring one’s own and others’ task performance, another’s actions are represented in a functionally equivalent way to one’s own. These neural signals were seen to be localized in the ventromedial prefrontal cortex (vmPFC) and anterior cingulate cortex (ACC) during Go trials and in the inferior and superior parietal lobe and the supplementary motor cortex during NoGo trials (Sebanz et al., 2007). Interestingly, simply thinking that another unseen participant is responding in the Go-NoGo experiment is enough to activate mental representations of the other, even when the other

participant is in reality the computer responding at random intervals (Tsai et al., 2008). This action co-representation is thus activated by believing another person is acting in conjunction with oneself regardless of their physical presence. In a separate condition where participants believed they were co-acting with the computer's responses, such neural markers for action representation were not seen, suggesting that it is the real or imagined presence of a biological agent that cause these representational activation patterns.

### *Social Coordination and Co-representation*

Other studies of dyadic social interaction involve spontaneous synchronization and unconscious mimicry. In a simple finger tapping task, participants were seen to coordinate their speed of finger movement upon visual information exchange with the other participant (Oullier et al., 2008). Participants also retained a social memory for the interaction, so that they did not return to their own preferred finger tapping speed after visual contact was cut off, but rather tapped slightly quicker if they had been slow originally or tapped much slower if they had been quick originally. This experiment therefore shows how an individual's behavior is modified through interactions with others such that they do not return to their original behavior after a social interaction. Likewise, Tognoli et al. (2007) found that people in this paradigm were more likely to show specific neural markers for coordinated behavior versus individual behavior. When participants tapped according to their own preferred rhythm, a specific EEG rhythm, the  $\phi_1$  complex, was seen in the right centro-parietal cortex, while the  $\phi_2$  complex was seen during coordinated behavior. One possible explanation for these findings is that the  $\phi_1$  complex reflects the inhibition of the mirror neuron system and unconscious mimicry, whereas the  $\phi_2$  complex represents its enhancement. This suggests that there are different neuromarkers for social interaction and coordination, similar to those previously shown to be involved in joint action and the Go-NoGo tasks (Newman-Norlund et al., 2007; Sebanz et al., 2007).

*Current Research*

Now that some of the main cognitive processes which are involved in understanding others have been set forth, along with neuroscientific data about social neural networks and cognitive aging, it is possible to postulate the psychological and neural underpinnings of social cognition in older adults, which may be beneficial to well-being and successful aging. We hypothesize that the neural and behavioral measures of other-regard in the laboratory would correspond to real world indices of social cognition, such as social network quality and extent and empathic concern. We further hypothesize that cognitive processes such as ToM, empathy and joint attention are involved in social cognition in the laboratory, and that brain regions associated with these cognitive processes would be differentially activated during other-regard.

This experiment investigated other-regard in a dyadic and individual Go-NoGo paradigm (Sebanz et al., 2006) in which participants were required to respond to the color of a ring on a picture of a hand so that the Go trial for one participant was the No-Go trial for the other. The index finger of the hand pointed either to the participant (congruent condition), to the other participant (incongruent condition), or directly ahead (neutral condition). However, the finger and hand were task-irrelevant. Participants who nonetheless attended to the hand, and therefore modified behavior according to whom it pointed at, were expected to show slower Go responses to their assigned ring color when the hand pointed to the other participant, since they thought it was the other participant's turn. Other-regard was behaviorally operationalized as a difference in reaction times (RTs) between trials when the hand pointed to self (congruent condition) and when the hand pointed to the other (incongruent condition). This difference in RTs was expected to be significantly greater than zero, whereby the congruent RT was subtracted from the longer incongruent RT. Likewise, RTs in the dyadic condition were expected to be longer than in the

individual condition since the presence of another person would activate neural representations of the other which would then influence their cognitive processing. This would therefore result in a longer RT on trials where the hand pointed to the other person.

Using the Lubben Social Network Scale (Lubben et al., 1996) and the Interpersonal Reactivity Index, which assesses self-report empathy (Davis, 1983), we predict that those who scored higher on these quantitative measures would also show these social markers in longer RTs and neural connections. The Interpersonal Reactivity Index has four subscales which measure perspective taking, empathic concern, personal distress and fantasization. Perspective taking and empathic concern positively contribute to the experience of empathy, while personal distress and fantasization negatively affect the experience of empathy. Personal distress is the amount of self-distress one feels in response to another person's distress and fantasization is how much one fantasizes or day dreams about what it would be like to be another person. We would expect that people with higher perspective taking and empathic concern would have more other-regard, while those who have more personal distress and fantasize more would exhibit less other-regard. Thus empathy, as a subset of ToM, is a necessary part of social cognition and it makes sense that people who are more empathic would have greater other-regard and perspective taking, and vice-versa. Likewise, people who show increased social cognition in the laboratory by their increased RTs in the incongruent condition would be expected to have more social interaction outside of the laboratory, as evidenced by their social network extent.

Since most of the research conducted thus far has only used EEG recording units with less than 64 electrodes, they have been unable to do source localization due to being under spatial Nyquist (Srinivasan et al., 1996). This project uses two dense array, 256-channel [electroencephalographic](#) (dEEG) recording units in a state-of-the-art linked configuration to

record participants' cortical activation simultaneously, which should not only help with source localization, but enable researchers to determine how participants interact with each other in real time on a neural basis. This would help ascertain which brain regions are involved in social cognition in older adults and whether these neural networks are different from those found in younger adults, due to potential changes in brain structure from aging. Although our neural findings are not reported here due to technological complications with the analyses, we set forth our expectations for neural processes involved in other-regard. Based on previous research, older adults are expected to show an increase in ventromedial prefrontal cortex, temporal-parietal junction and superior temporal sulcus processing during other-regard, as these regions are implicated in ToM and joint attention. Furthermore, the ACC has been shown to be involved in attentional shifting and joint attention, and would be expected to increase in the incongruent condition since the person would switch their attention from self to other when the hand was pointing at the other person. These activations are further expected to occur in the later epochs, such as 300-450 ms post-stimulus, as these cognitive processes recruit a wide-range of brain areas and occur after basic sensory perception such as visual processing of the stimuli (Sebanz et al., 2006; Sebanz et al, 2007).

In the earlier epochs, such as P1 or 100 ms post-stimulus, it is expected that there will be a decrease in neural signals localized in the occipital cortex when the hand is pointing at the other person. This lack of visual response to the incongruent condition is due to the fact that the person expects it to be the other participant's turn and so does not need to attend to the hand that is not pointing at themselves. However, if they did not take into account the direction of the pointing finger, then they would be expected to show an equal response to both congruent and incongruent stimuli, since they would only be responding to the color of the ring. Such

participants would not be expected to show other-regard in the form of the longer RT in the incongruent condition. Likewise, participants who exhibit other-regard are expected to show an increase in the motor cortex, more specifically in M1 and the premotor areas, during the incongruent trials. This effect would be seen around or after 300 ms post-stimulus, which is when most participants are expected to respond to the stimulus with a button press. However, their neural signals should be greater than when in the congruent condition because they would be mentally representing the other participant's response as their own, since they expected the other participant to respond, and then overrode this representation with their own motor response. In this way, the effects of other regard can be seen even in the simple perceptual processes such as vision and motor movement.

Lastly, it is hypothesized that the neural signals would positively correlate with participant's behavioral responses. Therefore, people who showed more other-regard by taking longer to respond in the incongruent condition would be expected to have greater activation in brain regions associated with other-regard and social cognition. Likewise, it is expected that participants' neural activation would correlate with their social network extent. This real world index of social cognition would be beneficial to showing how the findings of this empirical research would mirror real life social interaction and quality. In this way, the differential activation of certain neural networks can be compared to social cognition outside of the laboratory, and implicated in the cognitive well-being in older adults. Through these comparisons it is posited that efficient neural networks can be found which correlate with better social cognition, as evidenced by participants' other-regard in RT differences, empathy subscales and social network quality and extent.

## Methods

### *Participants*

In this study, 43 older adults from the Claremont and Upland communities were recruited via Craigslist and personal reference, ranging from ages 54 to 89 ( $M = 67.8$ ,  $SD = 10.0$ ). 16 men and 27 women participated. Out of the dyad groupings, 21 people were strangers to their partner and 22 people knew their partner (4 were friends and 18 were married or dating). The 14 participants who showed the expected behavioral effect consisted of 9 women and 5 men, with ages ranging from 59 to 86 ( $M = 67.1$ ,  $SD = 8.8$ ). Participants from various racial/ethnic, academic, religious and socioeconomic backgrounds were equally represented.

### *Materials*

Participants were given informed consent prior to starting the experiment and debriefed upon completing the experiment. Participants' real world social behavior such as empathy and the extent and quality of social networks were assessed using self-report measures (Davis, 1983; Lubben et al., 2006; See Appendixes A and B). Visual stimuli were presented using EPrime software (Psychological Software Tools, 2002; See Appendix C) and EEG data recorded in NetStation. Behavioral and neural analyses were done using Matlab and SPM8.

### *Procedure*

In this experiment, participants were asked to attend to visual stimuli on a computer screen (See Figure 1). After a 500ms fixation cross, they were asked to respond to a picture of a hand pointing either straight ahead, to the left or to the right. On the hand was a grey ring, which after 500 ms changed colors to either red or green. The participant sitting to the left of the computer screen responded to a red ring and the participant sitting to the right responded to a green ring. They were asked to respond as quickly as possible by pressing a button on a response box pad that corresponded to their specific ring color (1 for a red ring or 4 for a green ring). The

experiment consisted of 5 blocks of 102 trials each (510 trials total), which were done in the dyadic condition and the individual condition. In the individual condition, participants responded to the same color ring as in the dyadic condition and ignored the other ring color when it was presented. Participants responded using only their dominant hand. Participants' neuronal cortical activity was measured during the experiment using simultaneous recordings of two dense-array, 256-channel electroencephalographic (dEEG) recording units that were temporally linked. This provided millisecond accurate recordings of event related potentials (ERPs) to show the activity of the two brains in dyadic interaction.

[Place Figure 1 About Here]

#### *Data Analysis*

For the behavioral results, a linear regression was used to determine the correlation strength between social network size and other-regard, and between empathic concern and other-regard in the implicit turn taking task.  $R^2$  values were calculated on these independent variables using standard statistical procedures. T-tests were also conducted on the group and individual reaction times to see if the two conditions (hand pointing at other and hand pointing at self) were significantly different from each other.

#### Results

Other-regard was behaviorally operationalized as a difference in reaction times (RTs) between trials when the hand pointed to self and when the hand pointed to the other (Other-Self, or Incongruent-Congruent).

#### *Self-Report*

For the Lubben Social Network Scale, it was found that males had a significantly smaller social network than females (Mean Male = 14.9, SD = 5.2; Mean Female = 18.4, SD = 5.6;

$t(1,40) = -2.019, p = 0.025$ , one-tailed; See Figure 2). There was no significant effect found for age and social network extent ( $r = 0.214, p = 0.174, R^2 = 0.034, \beta = 1.392$ ).

[Place Figure 2 About Here]

For the Interpersonal Reactivity Index, empathic concern was marginally less in men than in women (Mean Male = 49.1, SD = 7.3; Mean Female = 52.9, SD = 9.9;  $t(1,41) = -1.330, p = 0.096$ , one-tailed; See Figure 3). Age did not have any significant effect on empathic concern ( $r = -0.086, p = 0.584, R^2 = -1.602, \beta = 1.273$ ). For fantasization scores, neither gender nor age played a role in the scores (Mean Male = 37.8, SD = 11.6; Mean Female = 42.5, SD = 10.7;  $t(1,41) = -1.339, p = 0.187$ , two-tailed;  $r = -0.281, p = 0.068, R^2 = -4.165, \beta = 1.532$ ). Personal distress did have a significant negative correlation with age ( $r = -0.334, p = 0.029, R^2 = -6.802, \beta = 2.028$ ; see Figure 4), but not with gender (Mean Male = 27.7, SD = 8.1; Mean Female = 30.0, SD = 11.8;  $t(1,41) = -0.727, p = 0.236$ , one-tailed). Age did not have any effect on perspective taking ( $r = 0.237, p = 0.124, R^2 = -1.557, \beta = 1.404$ ), nor did gender (Mean Male = 44.6, SD = 11.0; Mean Female = 47.2, SD = 10.3;  $t(1,41) = -0.801, p = 0.428$ , two-tailed).

[Place Figures 3 and 4 About Here]

### *Behavioral*

Three analyses serve as the foci of the results from the behavioral data. First, the expected RT difference at the group level was tested, given that this study was the first to apply this paradigm in older adults. It was found that 14 out of the 43 participants showed a statistically significant difference in RTs in the expected direction. There was an overall group effect ( $N=43$ ), such that the group was slower in responding on Go trials when the finger pointed to the other participant (Mean Difference = 15.0 ms, SD = 22.5 ms;  $t(1,42) = 4.312, p < 0.001$ ; See Figure 5). This difference was even greater in the 14 participants whose RT differences were

significantly greater than zero (Mean Difference = 24.5 ms, SD = 25.2 ms;  $t(1,13) = 4.564$ ,  $p < .001$ ; See Figure 6). There was no association found between RT difference scores and age ( $r = 0.102$ ,  $p = 0.514$ ,  $R^2 = -0.034$ ,  $\beta = 1.406$ , See Figure 7). However, when comparing age to the separate conditions, there was a positive correlation between age and congruent RTs ( $r = 0.519$ ,  $p < 0.001$ ,  $R^2 = 0.010$ ,  $\beta = 0.172$ , See Figure 8) and between age and incongruent RTs ( $r = 0.516$ ,  $p < 0.001$ ,  $R^2 = -0.045$ ,  $\beta = 0.167$ , See Figure 9). There was no significant difference in RT difference between the genders (Mean Male = 13.8 ms, SD = 26.7 ms; Mean Female = 12.3 ms, SD = 19.1 ms;  $t(1,41) = 0.211$ ,  $p = 0.833$ , two-tailed), nor when gender was compared to congruent RTs (Mean Male = 403.2 ms, SD = 66.9 ms; Mean Female = 380.2 ms, SD = 54.0 ms;  $t(1,41) = 1.234$ ,  $p = 0.224$ , two-tailed) or incongruent RTs (Mean Male = 417.0 ms, SD = 71.6 ms; Mean Female = 392.3 ms, SD = 58.7 ms;  $t(1,41) = 1.231$ ,  $p = 0.225$ , two-tailed).

[Place Figures 5-9 About Here]

Second, participants' individual RT differences were tested to whether there was a correlation with their social network and empathy scores. On empathy, only Personal Distress at another person's distress was found to decrease with increased RT difference, and therefore decreased with increased other-regard ( $r = -0.36$ ,  $p = 0.01$ ,  $R^2 = -6.464$ ,  $\beta = 0.47$ ; See Figure 10). No significant correlation was found for empathic concern, perspective taking or fantasization ( $r = -0.107$ ,  $p = 0.495$ ,  $R^2 = -24.5$ ,  $\beta = 1.010$ ;  $r = -0.241$ ,  $p = 0.120$ ,  $R^2 = -15.6$ ,  $\beta = 0.852$ ;  $r = -0.078$ ,  $p = 0.617$ ,  $R^2 = -10.4$ ,  $\beta = 0.795$ ). Finally, there was a marginal effect suggesting an association between increased RT difference and better quality and extent of social networks ( $r = 0.20$ ,  $p = 0.11$ ,  $R^2 = -6.216$ ,  $\beta = 0.39$ ; See Figure 11).

[Place Figures 10 and 11 About Here]

*Neural*

Due to unforeseen technical difficulties and potential data artifacts, analyses of neural metrics are still ongoing, but the behavioral associations found thus far are promising for the identification of neural signals that associate with both other-regard and real-world social network extent and quality, and for the localization of those signals. For the future neural analyses, only the 14 participants who showed the statistically significant behavioral RT difference will be considered. It is unclear what cognitive processes the other participants were engaging in, as they did not show other-regard to the same extent, and so analyzing their neural data would be inconclusive.

### Discussion

To date, the majority of prior research on social cognition and the cognitive processes that underlie social interaction has not focused on older adults. With recent evidence suggesting that social network extent and a mentally active lifestyle can prevent cognitive decline and decrease the risk of age-related neurological diseases such as dementia and Alzheimer's, it is important to investigate social cognition in older adults and how it benefits well-being and cognitive outcomes later in life (Cohen & Willis, 1985; Zunzunegui et al., 2003; Hertzog et al., 2009). There are many different cognitive processes that are required to have effective social interaction, such as theory of mind (ToM), empathy, joint attention and executive functioning. This study sought to understand the cognitive processes involved in social cognition through behavioral and neural indices of other-regard. Based on a "social Simon task" that Sebanz et al. (2006) used with younger adults, older participants were expected to demonstrate social cognition and other-regard by longer reaction times to stimuli that implicitly referred to the other participant. Although the neural analyses are still forthcoming, the behavioral and self-report

results from this implicit turn-taking task shed light on social cognition in older adults and some of the effects of social cognition outside the laboratory.

Our results showed that older adults do show the Simon effect in an implicit turn-taking task, whereby they take longer to respond to stimuli that refer to the other participant. This other-regard was operationalized as the difference between reaction times to congruent (hand pointing to self) and incongruent stimuli (hand pointing to other person). Across the group, participants were seen to show this effect even if it was not statistically significant on an individual level. 14 participants did have a statistically significant reaction time difference, suggesting that they had more efficient social cognition processes and neural networks. Importantly, there was no relationship between age and reaction time difference, since otherwise the paradigm would not have accurately measured cognitive other-regard but rather motor reflex times. As can be seen by the correlations between age and the raw scores (congruent RTs and incongruent RTs), there is an effect due to age which is to be expected, since people move more slowly as they get older. However, this motor effect is negated by subtracting the two conditions within subjects, so that participants' slowed RTs due to other-regard and cognitive processing is able to be measured.

Our next hypothesis was that other-regard measured in the laboratory would correlate with social network extent in the real world. This was shown to be true, as participants who had greater reaction time differences between the two stimuli conditions tended to have a larger social network than people who did not show this behavioral effect. Although this correlation was not statistically significant ( $p = 0.11$ ), it was trending in the positive direction. This suggests that the paradigm accurately measured social cognition and that participants who have more social interaction on a regular basis will have better social cognition, and vice versa.

Our last hypothesis was that other-regard reaction time differences would correlate with empathy. Of the four subscales on the empathy self-report measure (empathic concern, perspective taking, personal distress and fantasization), only personal distress correlated with other-regard. Personal distress is the amount of self-distress one feels in response to another person's distress and is related to one's ability to regulate emotion. Previous research has shown that emotion regulation is positively related to feelings of concern for the other person (Derryberry & Rothbart, 1988; Eisenberg et al., 1994). However, people who experience their emotions intensely, especially negative emotions, are likely to experience personal distress, which is an aversive emotional reaction, such as anxiety or discomfort based on the recognition of another's emotional state or condition (Davis, 1983; Eisenberg et al., 1991). Interestingly, people prone to personal distress may present deficits in self-other distinctiveness as they are not able to differentiate between their own pain and the pain another person feels (Decety & Jackson, 2006). This is supported by our study, since participants who had higher scores on personal distress showed decreased other-regard, suggesting a confusion or lack of distinction between self and other. Furthermore, heightened personal distress can lead to an egoistic motivation to reduce that distress by withdrawal or another aversive response. This would lead to a decrease in other-regard in social interaction since people would be focusing on their own emotional distress and not the other person (Singer & Lamm, 2009). This is also implicated by the results in our study and suggests that people who focus on themselves exclusively or are unable to differentiate between self and other will be less empathic, have more personal distress and be less likely to have other-regard in social situations.

Interestingly, age was seen to negatively correlate with personal distress, so that as people become older they are less likely to feel distress at another person's distress. While

correlation does not equal causation, this suggests that as people age they are less likely to respond negatively to other's emotional states and so have better social cognition. While it is true that older people could simply not care about other people's distress, it seems unlikely that this would be the case. As personal distress prevents the experience of empathy, it could be posited that older people would be more likely to empathize with others. However, as the empathic concern scale did not correlate with age, it is still unclear exactly what the relationship between empathy and age may be.

There were also some interesting relationships found between gender and self-report measures of social cognition. Empathic concern was seen to be significantly less in men than in women, which supports the existing body of research on this subject (Toussaint & Webb, 2005). One interesting study by Alwall & Hansen (2010) showed that women were better than men at gaze-cueing and joint attention, which are contributors to social cognition and empathy. Social network was also seen to be significantly less in men than women, which has been implicated in previous studies (Baron-Cohn, 2003). This is consistent with the idea that women are more sociable than men, and more empathetic. Interestingly, a study by Krach et al. (2009) suggested that women had greater ToM through activation of the medial prefrontal cortex when they believed they were playing the Prisoner's Dilemma Game with another person. If women are better at mentalizing and representing the psychological states of other people, then it would follow that they would have more social contacts and social cognition.

These findings demonstrate that older adults take into account the presence of another person during an implicit turn-taking task, thus replicating the findings from Sebanz et al. (2006). This other-regard was shown behaviorally in the laboratory and also correlates with indices of real-life social cognition, such as social network extent. While there was no

relationship between empathy (empathic concern) and other-regard, personal distress had a negative correlation with other-regard. This means that participants who reported more distress were less likely to show other-regard and have less efficient social cognition. Interestingly, this supports the current research on social network extent being a predictor of psychological well-being in aging (Gow et al., 2007). Since people who have more friends presumably have better social cognition due to mental stimulation from interacting with people on a regular basis, they would have less personal distress in their lives which would lead to well-being. Furthermore, the fact that other-regard correlated with social network extent shows that our results are measuring real-world effects and can be applied to more than just the laboratory setting. Thus, this study illustrates how social cognition in older adults is measurable in the laboratory and how it applies to real-life indices of social interaction and cognition.

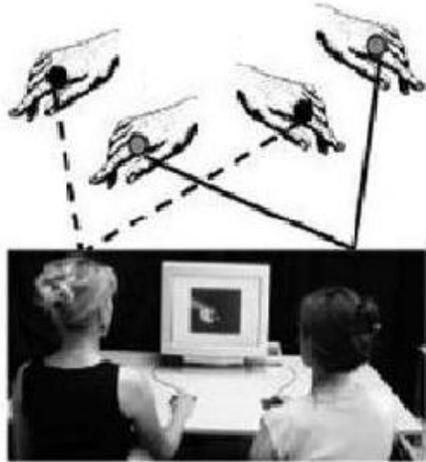
#### *Limitations and Directions for Future Research*

Unfortunately, the neural data for this project was not able to be presented due to time constraints on technical analysis and unforeseen complications with the software programming. However, once these obstacles are overcome, we expect that our previous hypotheses would stand. Namely, that older adults who show statistically significant other-regard would have differential activation in the TPJ, vmPFC, ACC and STS in the incongruent condition at 300 – 450 ms post-stimulus, since these areas are implicated in ToM, empathy, executive control of attention, and joint attention, all of which are necessary aspects of social cognition (Mason & Macrae, 2008; Swick, & Jovanovic, 2002; Sebanz et al., 2007). Furthermore, participants should have decreased activation in the occipital cortex at 100 ms post-stimulus in the incongruent condition, as they would take into consideration the image of the hand and not attend to it as much as in the congruent condition. Participants are also expected to show increased motor

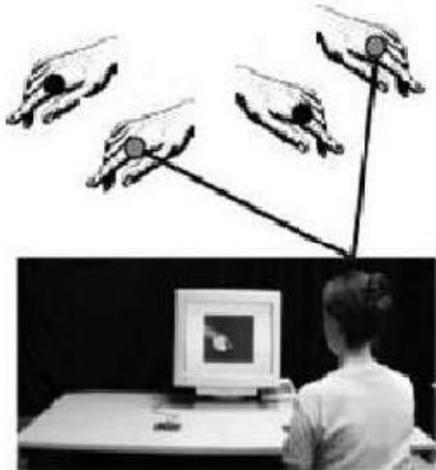
cortex activity at 300ms post-stimulus in the incongruent condition as the participant both anticipates the other participant's response and then responds themselves after 300 ms. This suggests both early and late neural processing that leads to behavioral other-regard. We expect that the neural signals would correlate with participant RT differences, as well as their social network extend and empathy self-report scores. Thus, continued research needs to be done to ascertain which neural networks are utilized in other-regard in older adults and whether these differ from earlier in life.

Another possible area in future research would be to investigate social cognition in older adults, but in different age ranges. For instance, different age groups such as 55-65 years old, 65-75, and 75 and older could potentially have very different neural and cognitive processing from each other. It would be beneficial to track the changes in social cognition, since a 55 year old physically active woman would have very different mental functioning than a home-bound 95 year old man. To categorize all people over a certain age range as the same seems to be an over-generalization, and it could be that researchers are missing out on important information regarding social-cognitive development. As can be seen by the correlation between age and personal distress found in this study, it would be interesting to discover why older people are less likely to feel personal distress. If they are better at regulating their emotions or distinguishing the self from others, it could benefit younger adults to understand what causes this so that they can have better social interactions and cognition as well. In this way, studying older adults leads to greater understanding of social aging and implications for people of all ages. By increasing our knowledge about changes in cognitive functioning and neural networks over time, as well as what can be done to mitigate cognitive decline, it will be possible to improve the well-being of older adults and enhance our social cognitive abilities.

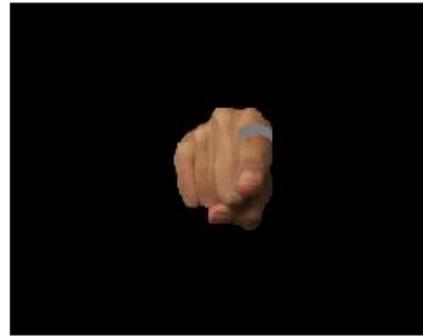
Paired Condition



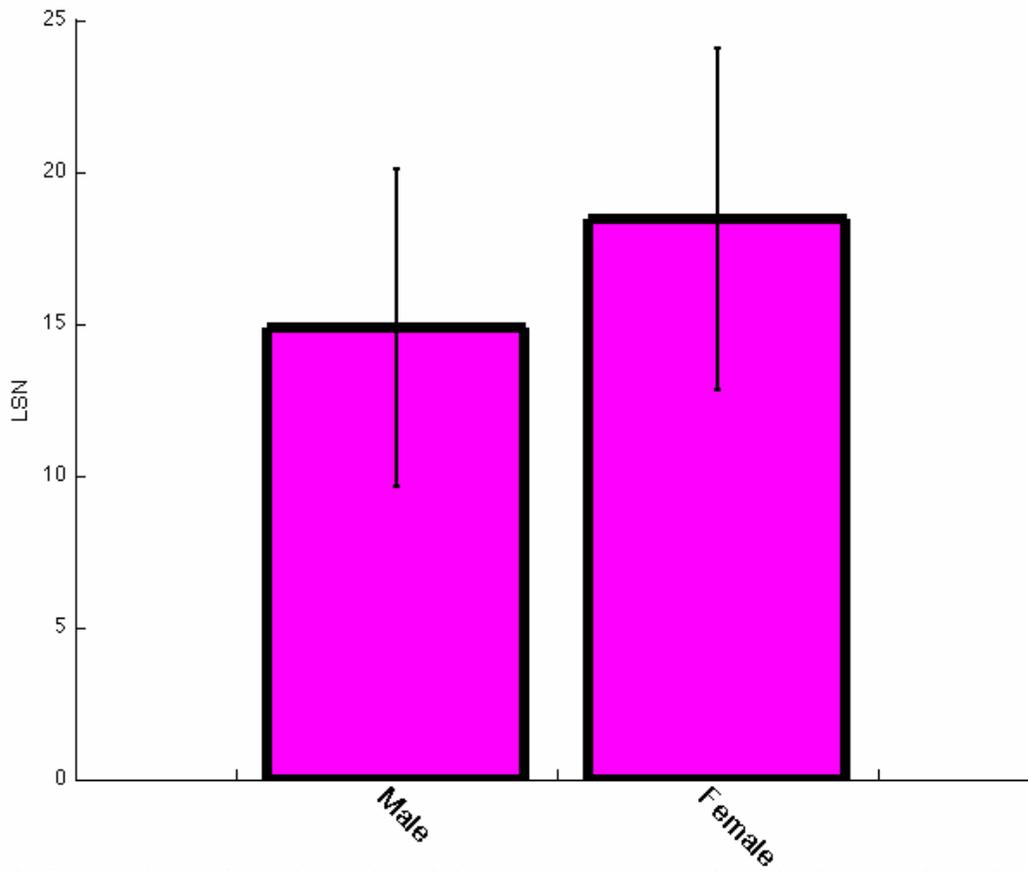
Individual Condition



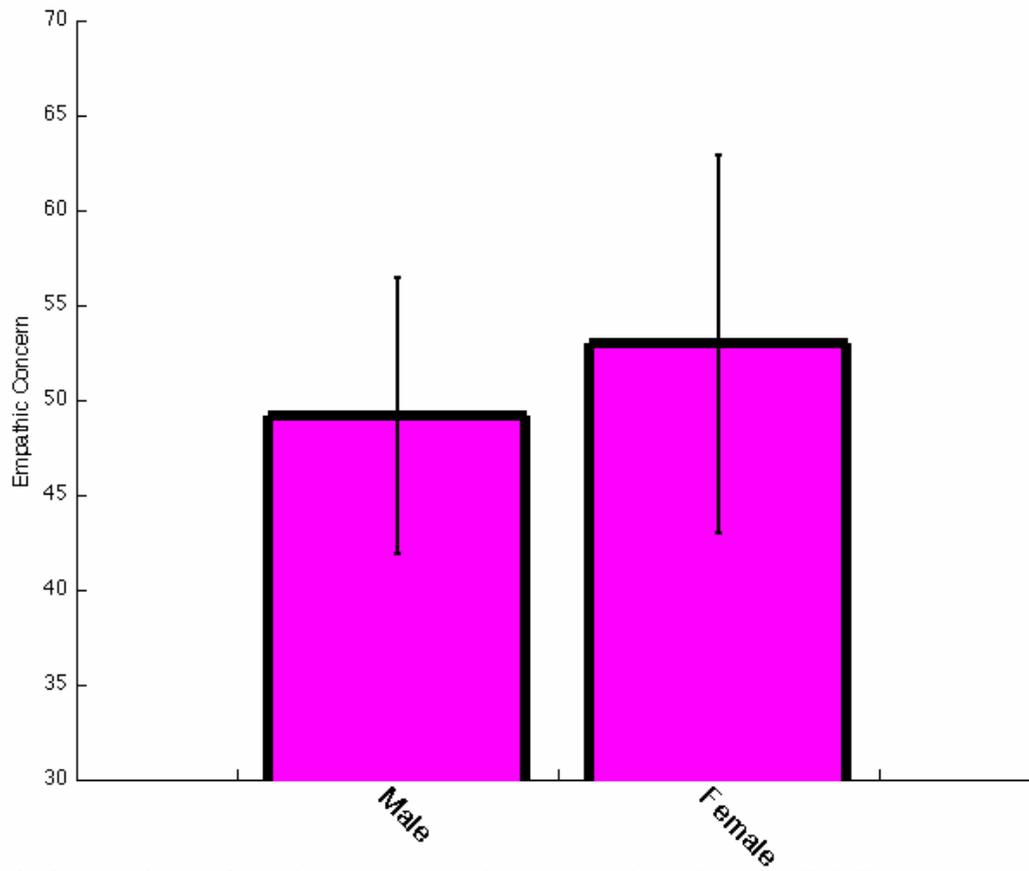
Possible Stimulus Images



*Figure 1.* Individual and paired conditions. Pictures of a hand pointing to the left, to the middle or to the right with a colored ring on the index finger are shown. In the example illustrated here, the left person is instructed to respond to red (dashed lines) and the right person is instructed to respond to green (solid lines). Stimuli that point away from the person are considered incongruent, while stimuli that point to the person are congruent. Stimuli that point straight ahead are neutral and used as a control. Diagram on left adapted from Sebanz et al. (2006); images on right created by researcher for this experiment.



*Figure 2.* Comparison of gender and social network size, based on the Lubben Social Network scale (LSN). Error bars represent the standard error of the mean  $t(1,40) = -2.019$ ,  $p = 0.025$ , one-tailed.



*Figure 3.* Comparison of gender and empathic concern, based on the IRI. Error bars represent the standard error of the mean  $t(1,41) = -1.330, p = 0.096$ , one-tailed.

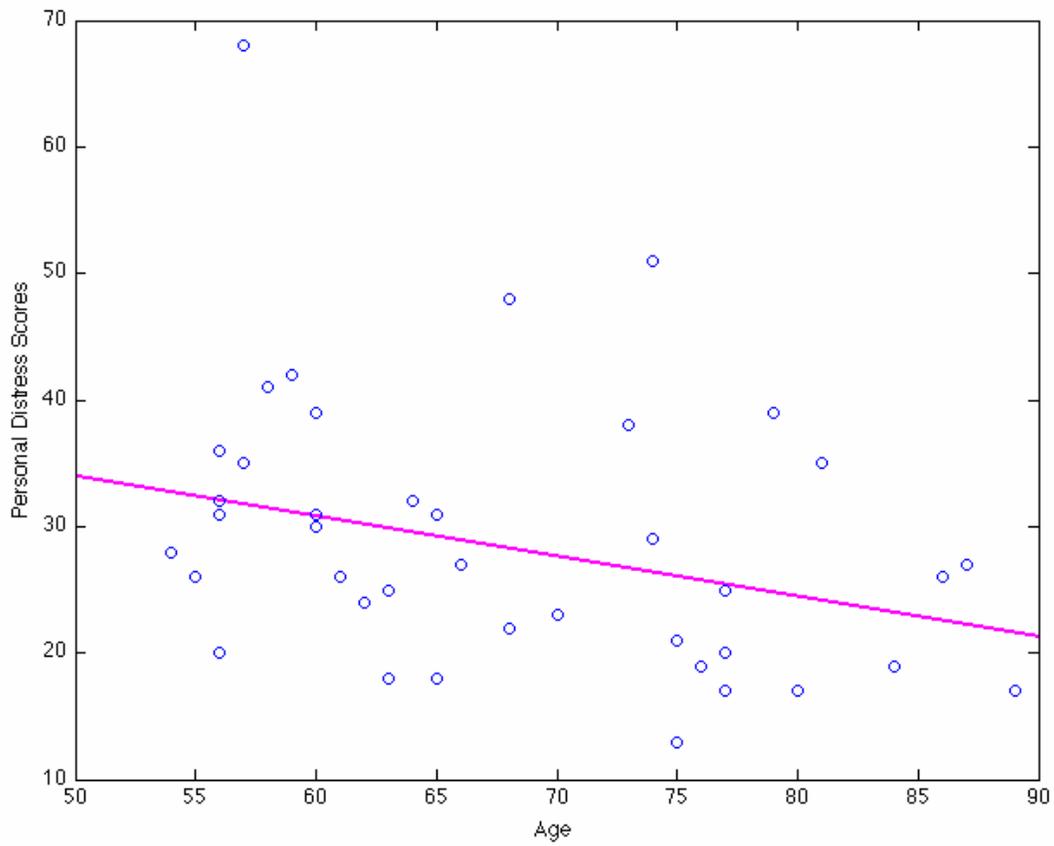
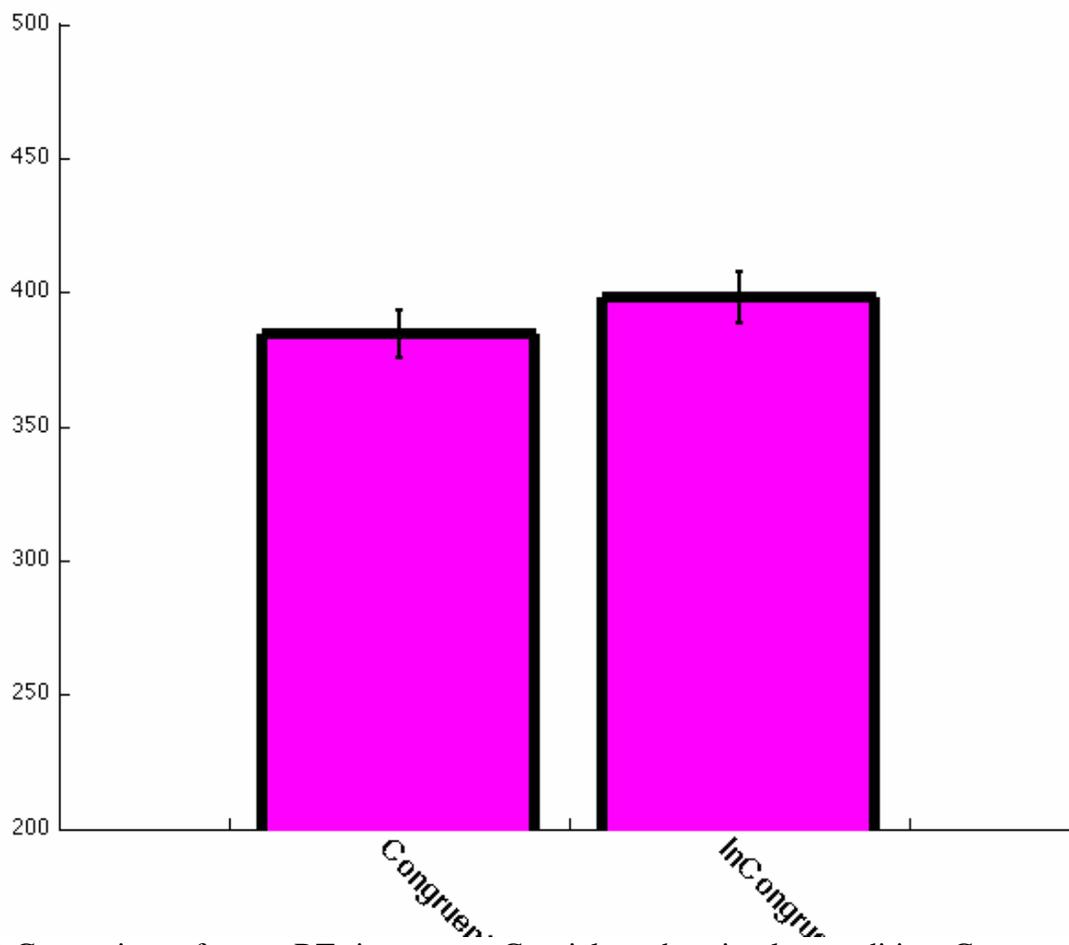
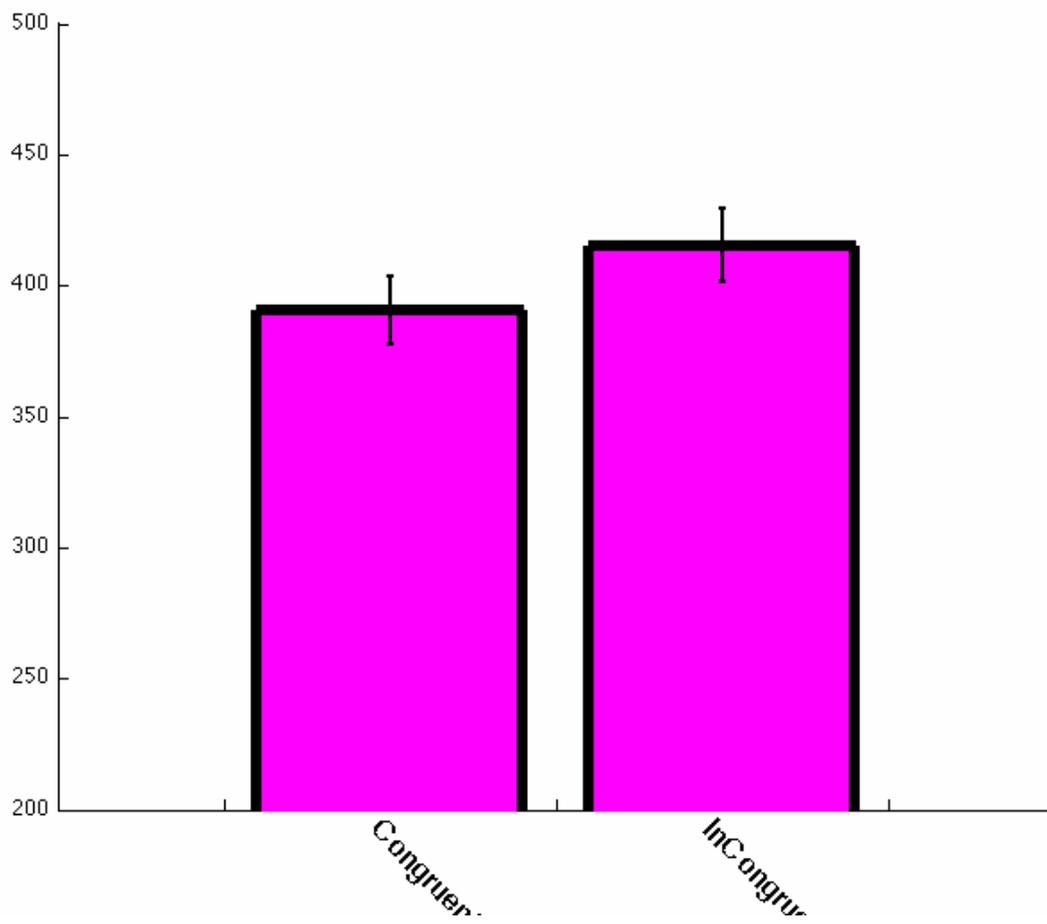


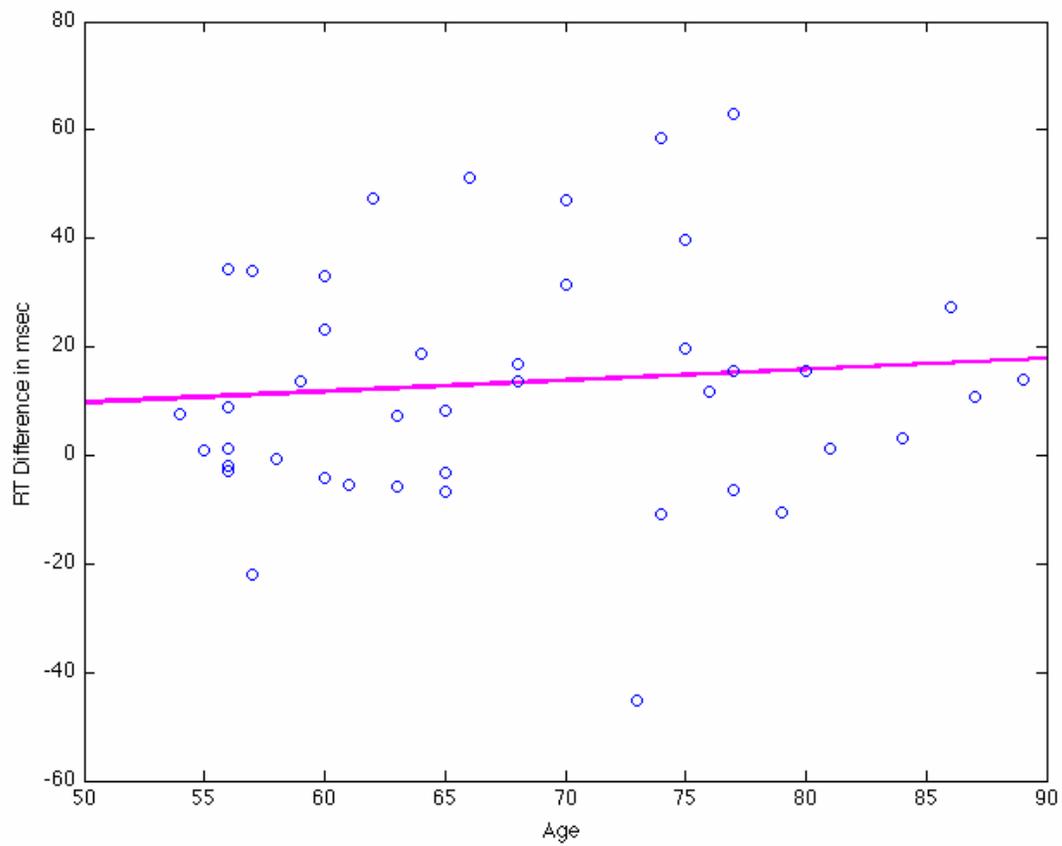
Figure 4. Comparison of age and personal distress, based on the IRI.  $r = -0.334$ ,  $p = 0.029$ ,  $R^2 = 0.078$ ,  $\beta = -0.334$ ,  $\text{intercept} = 20.28$



*Figure 5.* Comparison of group RTs in msec on Go trials to the stimulus condition. Congruent stimuli are pictures of the hand pointing to the self, and incongruent stimuli are pictures of the hand pointing to the other participant. Error bars represent the standard error of the mean.  $t(1,42) = 4.312, p < 0.001$ , two-tailed.



*Figure 6.* Comparison of statistically significant RTs on Go trials to the condition of the stimuli. Error bars represent the standard error of the mean.  $t(1,13) = 4.564, p < .001$ , two-tailed.



*Figure 7.* Comparison of Age of participant to RT difference.  $r = 0.102$ ,  $p = 0.514$ ,  $R^2 = -0.034$ ,  $\beta = 1.406$ .

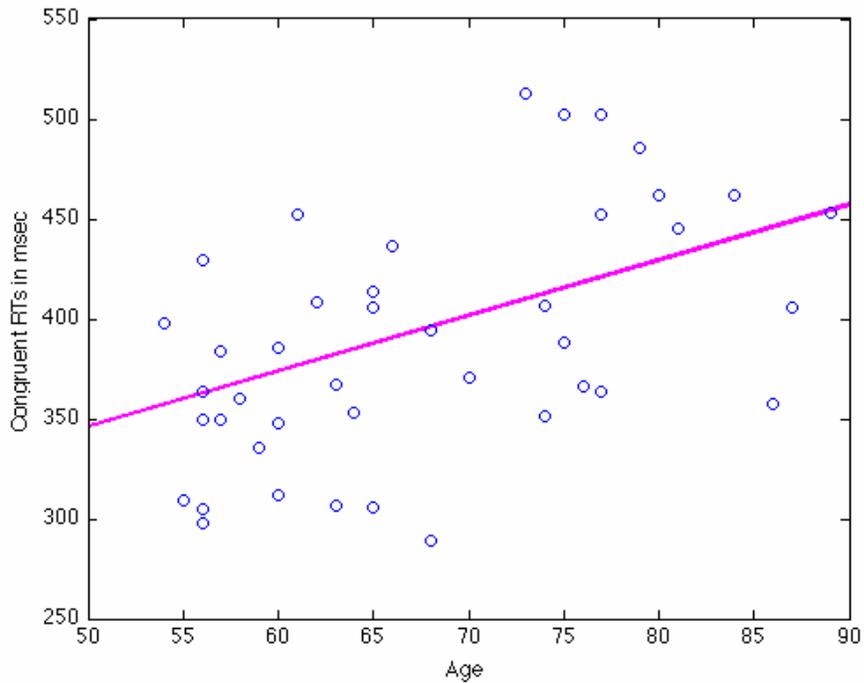


Figure 8. Comparison of Age to Congruent RTs.  $r = 0.519$ ,  $p < 0.001$ ,  $R^2 = 0.010$ ,  $\beta = 0.172$ .

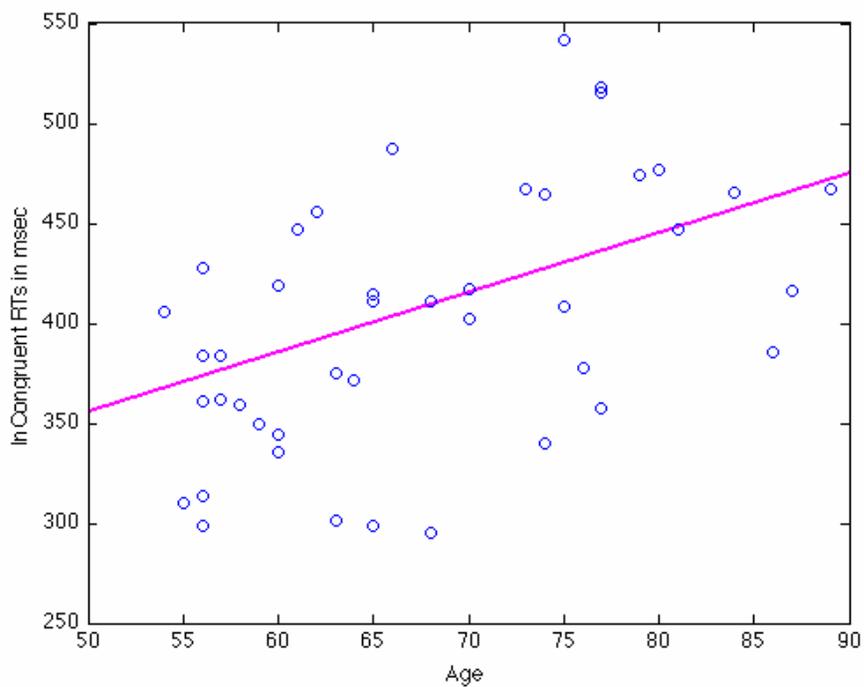
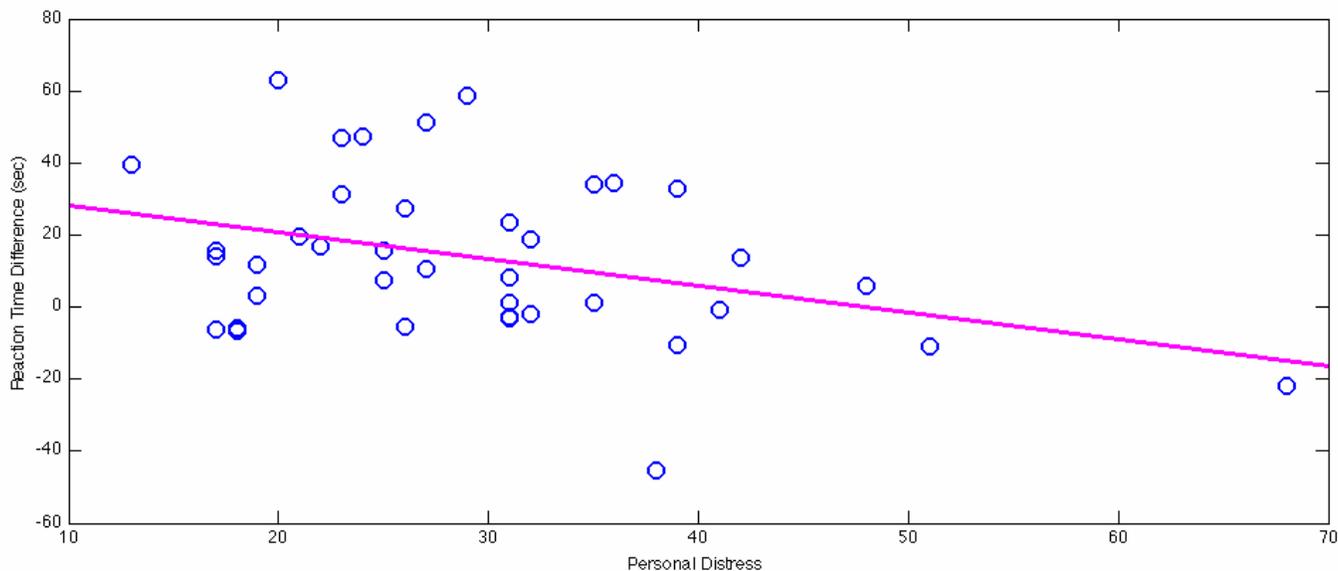
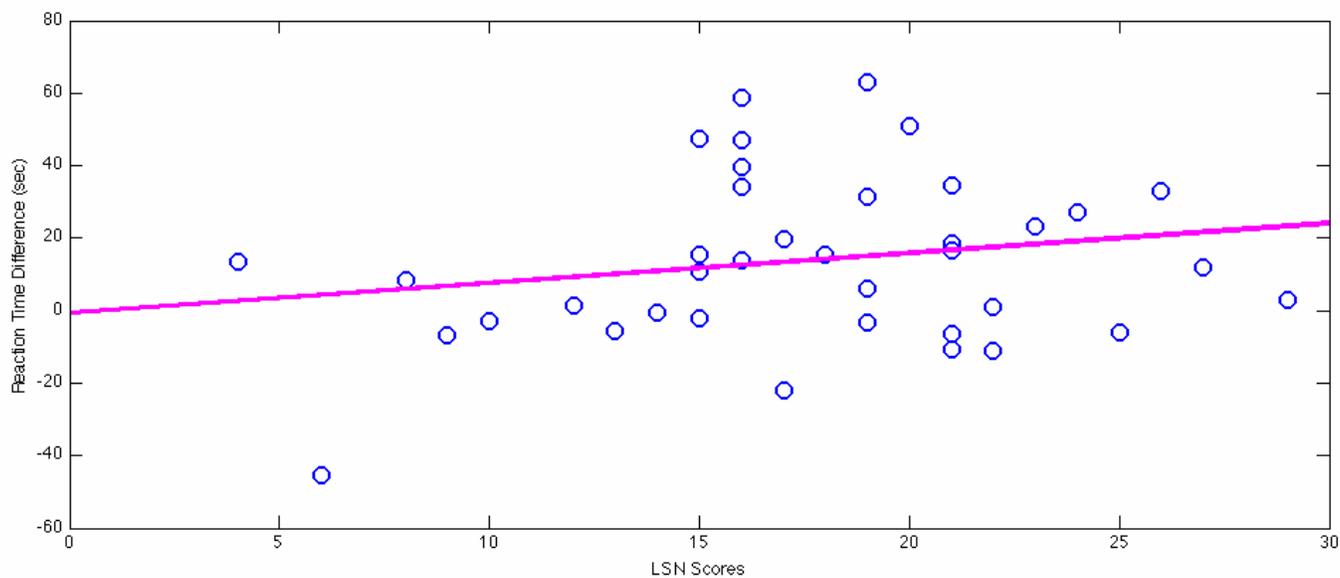


Figure 9. Comparison of Age to Incongruent RTs.  $r = 0.516$ ,  $p < 0.001$ ,  $R^2 = -0.045$ ,  $\beta = 0.167$ .



*Figure 10.* Correlation between differences in RTs and Personal Distress, based on the IRI.  $r = -0.36$ ,  $p = 0.01$ ,  $R^2 = -6.464$ ,  $\beta = 0.47$ .



*Figure 11.* Correlation of differences in RT to social network size, based on the Lubben Social Network scale (LSN).  $r = 0.20$ ,  $p = 0.11$ ,  $R^2 = -6.216$ ,  $\beta = 0.39$ .

## References

- Aine, C.J. (2011). Development and Decline of Memory Functions in Normal, Pathological and Healthy Successful Aging. *Brain Topography*, *24*, 323-339.
- Alwall, N. & Hansen, J.S. (2010). The gender difference in gaze-cueing: Associations with empathizing and systemizing. [Personality and Individual Differences](#), *49* (7), 729-732.
- Baron-Cohen, S. (2003). The essential difference. The truth about the male and female brain. Basic Books, New York.
- Batson, C.D., Batson, J.G., Singlsby, J.K., Harrell, K.L., Peekna, H.M., & Todd, R.M. (1991). Empathic joy and the empathy-altruism hypothesis. *Journal of Personality and Social Psychology*, *61*, 413-426.
- Baumeister, R.F., & Leary, M.R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497-529.
- Cabeza, R., Anderson N.D., Locantore, J.K., McIntosh, A.R. (2002). Aging gracefully: compensatory brain activity in high-performing older adults. *Neuroimage*, *17*, 1394-1402.
- Ciaramidaro, A., Adenzato, M., Enrici, I., Erkd, S., Pia, L. Bara, B.G. & Walter, H. (2007). The intentional network: How the brain reads varieties of intentions. *Neuropsychologia*, *45*, 3105-3113.
- Cohen, S., & Wills, T.A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, *98*, 310-357.
- Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Catalog of Selected Documents in Psychology*, *10*, 85.
- Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*, 113-126.

Decety, J., & Jackson, P. L. (2004). The Functional Architecture of Human Empathy. *Behavioral and Cognitive Neuroscience Reviews*, 3, 71-100.

[Decety, J., & Jackson, P. L. \(2006\). A Social-Neuroscience Perspective on Empathy. \*Current Directions in Psychological Science\*, 15\(2\), 54-58.](#)

Decety, J. & Lamm, C. (2006). Human Empathy through the Lens of Social Neuroscience. *TheScientificWorldJOURNAL*, 6, 1146-1163.

Derryberry, D., & Rothbart, M. K. (1988). Arousal, affect, and attention as components of temperament. *Journal of Personality and Social Psychology*, 55, 958-966.

Dunbar, R. (2008). Cognitive constraints on the structure and dynamics of social networks. *Group Dynamics: Theory, Research, and Practice*, 12(1), 7-16.

Eisenberg, N., Shea, C. L., Carlo, G., & Knight, G. (1991). Empathy related responding and cognition: A “chicken and the egg” dilemma. In W. Kurtines & J. Gewirtz (Eds.), *Handbook of Moral Behavior and Development, Vol. 2: Research* (pp. 63-68). Hillsdale, NJ: Lawrence Erlbaum.

Eisenberg, N., Fabes, R.A., Murphy, B., Karbon, M., Maszk, P., Smith, M., O'Boyle, C., & Suh, K. (1994). The relations of emotionality and regulation to dispositional and situational empathy-related responding. *J. Pers. Soc. Psychol.* 66, 776–797.

Eisenberg, N., Smith, C.L., Sadovsky, A., & Spinrad, T.L. (2004). Effortful control. In *Handbook of Self-Regulation*. Baumeister, R.F. and Vohs, K.D., Eds. The Guilford Press, New York. pp. 259–282.

Frischen, A., Bayliss, A., & Tipper, S. (2007). Gaze cueing of attention: Visual attention, social cognition, and individual differences. *Psychological bulletin*, 133(4), 694-724.

- Frith, C. D., and Frith, U. (1999). Interacting minds – a biological basis. *Science* 286, 1692–1695.
- Gow, A., Pattie, A., Whiteman, M., Whalley, L., & Deary, I. (2007). Social Support and Successful Aging. *Journal of Individual Differences*, 28(3), 103-115.
- Hendrie, H.C., Albert, M.S., Butters, M.A., Gao, S., Knopman, D.S., Launer, L.J. et al. (2006). The NIH Cognitive and Emotional Health Project: Report of the Critical Evaluation Study Committee. *Alzheimer's and Dementia*, 2, 12–32.
- Hertzog, C., Kramer, A.F., Wilson, R.S. & Lindenberger, U. (2009). Enrichment Effects on Adult Cognitive Development Can the Functional Capacity of Older Adults Be Preserved and Enhanced? *Psychological Science in the Public Interest*. 9(1), 1-66.
- Hugdahl, K., Westerhausen, R., Alho, K., Medvedev, S., Laine, M. & Hamalainen, H. (2009). Attention and cognitive control: Unfolding the dichotic listening story. *Scandinavian Journal of Psychology*. 50, 11–22.
- Humphreys, G.W. & Bedford. J. (2011). The relations between joint action and theory of mind: a neuropsychological analysis. *Exp Brain Res*, 211:357–369.
- [Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. \(2006\). Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain: An event-related fMRI study. \*Neuropsychologia\*, 44, 752-61.](#)
- Krach, S., Blümel, I., Marjoram, D., Lataster, T., Krabbendam, L., Weber, J., van Os, J., & Kircher, T. (2009). Are women better mindreaders? Sex differences in neural correlates of mentalizing detected with functional MRI. *BMC Neuroscience*. 10(9), 1-11.
- Lanzetta, J. T., & Englis, B. S. (1989). Expectations of cooperation and competition and their effects on observers' vicarious emotional responses. *J. Pers. Soc.Psychol.*, 56, 543–554.

- Lubben, J., Blozik, E., Gillmann, G., Iliffe, S., von Renteln Kruse, W., Beck, J. C., et al. (2006). Performance of an abbreviated version of the Lubben Social Network Scale among three community-dwelling older adult populations. *Gerontologist, 46*(4), 506-513.
- Luck, S. J. (2005). *An Introduction to the Event-Related Potential Technique*. Cambridge, Mass.: The MIT Press.
- Mason, M. F. & Macrae, C. M. (2008). Perspective-Taking from a Social Neuroscience Standpoint. *Group processes & intergroup relations, 11*(2) 215-232.
- Newman-Norlund, R. D., Bosga, J., Meulenbroek, R. G. J., & Bekkering, H. (2008). Anatomical substrates of cooperative joint-action in a continuous motor task: virtual lifting and balancing. *Neuroimage, 41*(1), 169-177.
- Oullier, O. de Guzman, G., Jantzen, K.J., Lagarde, J., Kelso, J.A.S (2008). Social Coordination Dynamics: Measuring human bonding. *Social Neuroscience, 3*(2), 178-192.
- Pelphrey, K. A., Viola, R. J., & McCarthy, G. (2003). When strangers pass: Processing of mutual and averted social gaze in the superior temporal sulcus. *Psychological Science, 15*, 598–603.
- Preston, S.D., & de Waal, F.B.M. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences, 25*, 1–72.
- Richardson, D., Dale, R., & Kirkham, N. (2007). The art of conversation is coordination. *Psychological Science, 18*(5), 407.
- Scholz, J., Triantafyllou, C., Whitfield-Gabrieli, S., Brown, E. N., & Saxe, R. (2009). Distinct regions of right temporo-parietal junction are selective for theory of mind and exogenous attention. *PLoS One, 4*(3), e4869.

- Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: bodies and minds moving together. *Trends in Cognitive Sciences*, *10*(2), 70-76.
- Sebanz, N., Knoblich, G., Prinz, W., & Wascher, E. (2006). Twin peaks: An ERP study of action planning and control in coacting individuals. *J Cogn Neurosci*, *18*(5), 859-870.
- Sebanz, N., Rebecchi, D., Knoblich, G., Prinz, W., Frith, C.D. (2007). Is it really my turn? An event-related fMRI study of task sharing. *Soc Neurosci*. *2*(2):81-95.
- Singer, T., Seymour, B., O'Doherty, J. P., et al. (2006). Empathic neural responses are modulated by the perceived fairness of others. *Nature*, *439*, 466–469.
- Singer, T. & Lamm, C. (2009). The Social Neuroscience of Empathy. *Ann. N.Y. Acad. Sci.*, *1156*, 81-96.
- Srinivasan, R., Nunez, P. L., Tucker, D. M., Silberstein, R. B., & Cadusch, P. J. (1996). Spatial sampling and filtering of EEG with spline laplacians to estimate cortical potentials. *Brain Topogr*, *8*(4), 355-366.
- Swick, D. & Jovanovic, J. (2002). Anterior cingulate cortex and the Stroop task: neuropsychological evidence for topographic specificity. *Neuropsychologia*. *40*, 1240–1253.
- Tisserand D.J., Jolles J. (2003) On the involvement of prefrontal networks in cognitive ageing. *Cortex*. *39*, 1107–1128
- Tognoli, E., Lagarde, J., DeGuzman, G., & Kelso, J. (2007). The phi complex as a neuromarker of human social coordination. *Proceedings of the National Academy of Sciences*, *104*(19), 8190.
- Toussaint, L. & Webb, J.R. (2005). Gender Differences in the Relationship Between Empathy and Forgiveness. *The Journal of Social Psychology*. *145*(6), 673–685.

- Tsai, C.-C., Kuo, W.-J., Hung, D. L., & Tzeng, O. J. L. (2008). Action co-representation is tuned to other humans. *J Cogn Neurosci*, *20*(11), 2015-2024.
- Tsai, C.-C., Kuo, W.-J., Jing, J.-T., Hung, D. L., & Tzeng, O. J.-L. (2006). A common coding framework in self–other interaction: evidence from joint action task. *Exp Brain Res*, *175*(2), 353-362.
- Uchino, B.N., Cacioppo, J.T., & Kiecolt-Glaser, J.K. (1996). The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*, 488-531.
- U.S. Census Bureau. (2010). Age Data of the United States.  
[http://www.census.gov/population/www/socdemo/age/older\\_2010.html](http://www.census.gov/population/www/socdemo/age/older_2010.html). Accessed 12/2/11.
- Vignemont, F. & Singer, T. (2006) The empathic brain: how, when and why? *TRENDS in Cognitive Sciences*. *10*(10), 435-441.
- Wang, Y., Zheng, Y., Lin, C., Wu, J. and Shen, D. (2011). Electrophysiological correlates of reading the single- and interactive-mind. *Frontiers in Human Neuroscience*, *5*(64), 1-10.
- World Health Organization. (2002). Active ageing: A policy framework. Geneva: WHO Ageing and the Life Course Section.
- Young, L., Dodell-Feder, D., & Saxe, R. (2010). What gets the attention of the temporo-parietal junction? An fMRI investigation of attention and theory of mind. *Neuropsychologia*. *48*, 2658–2664.
- Zunzunegui, M.-V., Alvarado, B.E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *Journal of Gerontology*, *58B*, S93–S100.

Appendix A  
Interpersonal Reactivity Index

Rate the following statements as best you can according to how well they describe you:

Does not describe me well	1	2	3	4	5	6	7	8	9	10	Describes me very well
------------------------------	---	---	---	---	---	---	---	---	---	----	---------------------------

- \_\_\_\_ 1. I daydream and fantasize, with some regularity, about things that might happen to me.  
\_\_\_\_ 2. I often have tender, concerned feelings for people less fortunate than me.  
\_\_\_\_ 3. I sometimes find it difficult to see things from the "other guy's" point of view.

- \_\_\_ 4. Sometimes I don't feel very sorry for other people when they are having problems.
- \_\_\_ 5. I really get involved with the feelings of the characters in a novel.
- \_\_\_ 6. In emergency situations, I feel apprehensive and ill-at-ease.
- \_\_\_ 7. I am usually objective when I watch a movie or play, and I don't often get completely caught up in it.
- \_\_\_ 8. I try to look at everybody's side of a disagreement before I make a decision.
- \_\_\_ 9. When I see someone being taken advantage of, I feel kind of protective towards them.
- \_\_\_ 10. I sometimes feel helpless when I am in the middle of a very emotional situation.
- \_\_\_ 11. I sometimes try to understand my friends better by imagining how things look from their perspective.
- \_\_\_ 12. Becoming extremely involved in a good book or movie is somewhat rare for me.
- \_\_\_ 13. When I see someone get hurt, I tend to remain calm.
- \_\_\_ 14. Other people's misfortunes do not usually disturb me a great deal.
- \_\_\_ 15. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.
- \_\_\_ 16. After seeing a play or movie, I have felt as though I were one of the characters.
- \_\_\_ 17. Being in a tense emotional situation scares me.
- \_\_\_ 18. When I see someone being treated unfairly, I sometimes don't feel very much pity for them.
- \_\_\_ 19. I am usually pretty effective in dealing with emergencies.
- \_\_\_ 20. I am often quite touched by things that I see happen.
- \_\_\_ 21. I believe that there are two sides to every question and try to look at them both.
- \_\_\_ 22. I would describe myself as a pretty soft-hearted person.
- \_\_\_ 23. When I watch a good movie, I can very easily put myself in the place of a leading character.
- \_\_\_ 24. I tend to lose control during emergencies.
- \_\_\_ 25. When I'm upset at someone, I usually try to "put myself in his shoes" for a while.
- \_\_\_ 26. When I am reading an interesting story or novel, I imagine how *I* would feel if the events in the story were happening to me.
- \_\_\_ 27. When I see someone who badly needs help in an emergency, I go to pieces.
- \_\_\_ 28. Before criticizing somebody, I try to imagine how *I* would feel if I were in their place.

## Appendix B

### LUBBEN SOCIAL NETWORK SCALE—6-Item Version

*FAMILY: Considering the people to whom you are related either by birth or marriage*

1. How many relatives do you see or hear from at least once a month?

0 = none    1 = one    2 = two    3 = three or four    4 = five thru eight    5 = nine or more

2. How many relatives do you feel close to such that you could call on them for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

3. How many relatives do you feel at ease with that you can talk about private matters?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

*FRIENDSHIPS: Considering all of your friends including those who live in your neighborhood.*

4. How many of your friends do you see or hear from at least once a month?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

5. How many friends do you feel close to such that you could call on them for help?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

6. How many friends do you feel at ease with that you can talk about private matters?

0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

## Appendix C

### EPrime Experimental Design

