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Mental state understanding during aging: an examination of cognitively effortful and cognitively efficient mechanisms

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MENTAL STATE UNDERSTANDING DURING AGING:
AN EXAMINATION OF COGNITIVELY EFFORTFUL
AND COGNITIVELY EFFICIENT MECHANISMS

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

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School of Psychological Sciences
Educational Psychology

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has been approved as meeting the requirements for the Degree of Doctor of Philosophy in College of Education and Behavioral Sciences in School of Psychological Sciences, Program of Educational Psychology

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ABSTRACT

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The human ability to understand the mental states of others is a fundamental skill necessary for social interactions. Some researchers have argued that two cognitive systems underlie mental state understanding; one that is cognitively efficient and another that is cognitively effortful and partially mediated by explicit processes. The purpose of the current study was to investigate mental state understanding in older adults (aged 60 to 87) from the framework of examining these two systems. To achieve these goals, the current study used two tasks that differed in the degree to which they involve implicit versus explicit processes. A level-1 visual perspective taking task was employed to examine if older adults showed evidence of automatically processing another individual's perspective (in this task, the "other" perspective was a digital avatar displayed on a computer screen). A dual task was utilized to examine the impact of inhibitory control on level-1 visual perspective taking. Explicit mental state understanding was examined with a theory of mind story task. Finally, the digit span and symbol span from the Wechsler's Adult Intelligence Scale-IV were used as measures of verbal and spatial working memory respectively.

Results indicated that older adults (n = 42) were prone to egocentric interference effects, suggesting that older adults own perspective interferes with taking another

individual's perspective. No evidence was found that older adults automatically process another individual's perspective; thus, no evidence was found of a cognitively efficient mechanism for mental state understanding during aging. The dual-task results indicated that only the self perspective was significantly slower for the dual task compared to the level-1 visual perspective taking alone.

A hierarchical regression was conducted to examine the degree to which verbal and spatial working memory mediated theory of mind and level-1 visual perspective taking performance. Results indicated that verbal but not spatial working memory contributed to theory of mind performance. Verbal and spatial working memory did not contribute to level-1 visual perspective taking. This was the first study to examine cognitively efficient and cognitively effortful mechanisms in mental state understanding in older adults. The results offer an explanation for previous research that suggests mental state understanding in older adults declines above what can be explained by general cognitive decline. Furthermore, the results offer several theoretical contributions regarding the nature and limits of a cognitively efficient system for mental state understanding.

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CHAPTER I

INTRODUCTION

The human capacity for mental state understanding far surpasses that of any other

species and is a fundamental cognitive capacity necessary for everyday social interactions

(Saxe, 2006). Mental state understanding is considered to include a wide range of skills,

such as decoding nonverbal behavior, emotion perception, and reasoning about other's

mental states. The ability to understand the contents of another individual's mind is of

such vital importance that when this ability is impaired, significant social deficits are

observed (Hughes, Soares-Boucaud, Hochmann, & Frith, 1997). For example, research

has found deficits in mental state understanding are significantly correlated with

difficulties in everyday social interactions in autism spectrum disorders, (Baron-Cohen,

Howlin, & Hill, 1997; Baron-Cohen, Leslie, Frith, 1985), schizophrenia (Penn, Corrigan,

Bentall, Racenstein, & Newman, 1997), post-traumatic stress disorder (Schmidt &

Zachariae, 2009), and traumatic brain injuries (Bibby & McDonald, 2005). Conversely,

there is evidence to suggest that individuals who excel in mental state understanding are

more likely to interact with others cooperatively (Paal & Bereczkei, 2007). To illustrate

the importance of judging the contents of another individual's mind, consider the

following situation: yesterday I was struggling with two children and several pieces of

luggage before ascending an escalator at the airport. Realizing someone was behind me,

I glanced back and gauged that the woman was sympathetic regarding my struggles.

Concluding that the woman was not in a rush nor irritated at my debacle, I continued ahead of her; however, if I had judged that the woman was irritated and or in a hurry, I would have stepped aside to let her pass. Despite the continuous stream of complex cognitive processing involved in a social interaction such as this, the human brain handles the input and drives behavior with little effort (Beer & Ochsner, 2006).

As illustrated in the example above, successful human interaction depends, in part, on the ability to understand the intentions, beliefs, and desires of others (Stone, 2005). During aging, impairments in mental state understanding have been well documented (e.g., Slessor, Phillips, & Bull, 2007; Sullivan & Ruffman, 2004) although the mechanisms underlying the observed deficits are not clearly understood (Moran, 2013). This is in large part due to the complex cognitive processes involved in understanding other's mental states. For instance, cognition involved in understanding other people's mental states includes processes such as: visual-perception of other agents, usually conspecifics (Heider & Simmel, 1994); attentional processes (Leslie, Friedman, & German, 2004); facial expression processing, including eye gaze direction (Langton, Watt, & Bruce, 2000); emotion processing (Adolphs, 2002), and executive functioning (Ahmed & Miller, 2011).

The underlying cognitive processes involved in mental state understanding have been argued to include both cognitively effortful as well as fast and automatic processes (Frith & Frith, 2008; Apperly & Butterfill, 2009; Sabbagh, 2004). Theory of mind, the ability to make mental state inferences in order to predict behavior (Premack & Woodruff, 1978), involves explicit cognitive processes. For instance, if you were to predict where I am going to search for my computer, then you would need to consider my

belief regarding where my computer is located. Thus, tasks that measure theory of mind ability require that participant's explicitly reason about mental states, such as beliefs. Studies with children and adult samples suggest that theory of mind correlates with executive functioning (e.g., Rowe, Bullock, Polkey, & Morris, 2001; Sabbagh, Xu, Carlson, Moses, & Lee, 2006), working memory (e.g., Lin, Keysar, & Epley, 2010), and verbal ability (e.g., Astington & Jenkins, 1999; Dunn & Brophy, 2005; Hughes, 1998; Lohmann & Tomasello, 2003; Milligan, Astington, & Dack, 2007), demonstrating that individual differences in mental state understanding are partially mediated by cognitively effortful processes.

Unlike the cognitive resources required for theory of mind tasks, other aspects of mental state understanding may not involve cognitively effortful processes. One such capacity is the ability to differentiate between our own perspective and the perspective of another individual. Research suggests that taking the visual perspective of another individual is less dependent on executive functioning, memory, and language (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). Compared to explicit theory of mind abilities, which emerges between the ages of 3 and 4 along with the burgeoning cognitive capacities of executive function, working memory and verbal ability, the capacity for visual perspective taking emerges relatively early (Moll & Tomasello, 2006; Song & Baillargeon, 2008). For instance, indirect evidence from infant studies suggests that 14-month olds are capable of taking into account the visual perspective of another individual (Sodian, Thoermer, & Metz, 2007). Thus, it has been argued that mental state understanding also involves cognitively efficient processes in addition to cognitively effortful resources (Qureshi, Apperly, & Samson, 2010). The purpose of the current

study was to explore mental state understanding during aging utilizing two tasks that vary in the degree to which they require cognitively effortful versus efficient processes.

Mental State Understanding During Aging

Over the past decade and a half, several studies have investigated if mental state understanding declines with age (e.g., Bailey & Henry, 2008; Happé, Winner, & Brownell, 1998). A recent meta-analysis found moderate to large effects in favor of young compared to older adults on all mental state tasks examined (i.e., tasks utilizing multiple modalities and a variety of task demands, Henry, Phillips, Ruffman, & Bailey, 2012); however, research examining mental state understanding in older adults is complicated by age-related cognitive decline. That is, during aging several cognitive capacities decline that are related to individual differences in mental state understanding. Most of the studies examining mental state understanding during aging have used theory of mind tasks, which are partially mediated by explicit cognitive processes. Since aging is associated with declines in executive functioning (e.g., Verhaeghen, 2011) and working memory (e.g., Bopp & Verhaeghen, 2005), it is necessary to extricate the degree to which age-related decline in mental state understanding is influenced by these cognitive resources (Rakoczy, Harder-Kasten, & Sturm, 2011).

Studies that have used theory of mind story tasks, which involve reading a short vignette and inferring the mental state of a character, suggest that mental state deficits during aging are at least partially mediated by age-related cognitive decline (e.g., German & Hehman, 2006). Studies using less verbally demanding tasks (e.g., cartoon tasks and static pictures of eyes), however, also report age-related deficits, which may be influenced by declining cognitive processes, such as working memory (Henry et al.,

2012). One of the goals of the current study was to investigate the degree to which working memory mediates mental state understanding during aging. Specifically, I examined how verbal and spatial working memory contributed to a theory of mind story task as well as a task that involves cognitively efficient processes.

Level-1 Visual Perspective Taking

Level-1 visual perspective taking is demonstrated when a person can visually track what someone else can and cannot see (Flavell, Everett, Croft, & Flavell, 1981). Level-1 visual perspective taking differs from theory of mind tasks in that a participant needs only to consider the visual viewpoint of another individual and not their mental state. A series of studies using a level-1 visual perspective task found that children and adults are prone to interference from inconsistent perspectives (Samson et al.,2010; Surtees & Apperly, 2012; Qureshi et al., 2010). Specifically, Samson et al. (2010) found that participants demonstrated two types of interference effects: egocentric (i.e., participants were slower and more error prone when asked to judge an agent's perspective when their own perspective was inconsistent) and altercentric (i.e., participants were slower and more error prone when asked to judge self-perspective when the agent's perspective was inconsistent). Samson et al. interpreted the altercentric interference as evidence that participants spontaneously judged the agent's perspective even when they were not instructed to do so.

In a study using a dual-task design, Qureshi and colleagues (2010) employed the level-1 visual perspective taking task with a secondary executive functioning task. The aim of using the dual-task paradigm was to investigate the role of executive processes on the primary perspective taking task. Based on the results, the authors concluded that

level-1 visual perspective taking does not require executive functioning. Collectively, the results from these studies suggest that information processing for some aspects of mental state understanding may proceed relatively efficiently (Samson et al., 2010; Surtees & Apperly, 2012; Qureshi et al., 2010). To my knowledge, no studies have investigated level-1 perspective taking in older adults. In contrast to the age-related deficits found in tasks that have been shown to require explicit cognitive processes (i.e., theory of mind tasks), level-1 perspective taking may remain relatively intact during aging. This hypothesis has not yet been explored and was one of the primary goals of the current study.

Need for the Study

Studies examining mental state understanding during aging have used theory of mind tasks, which have been shown to involve high-level cognitive processes (e.g., McKinnon & Moscovitch, 2007; Slessor, Phillips, & Bull, 2007). Consequently, it is necessary to examine the degree to which age-associated decline in mental state understanding is mediated by general cognitive impairments versus a specific impairment in understanding mental states. The literature to date suggests that mental state understanding deteriorates during normal aging (Henry et al.,, 2012); however, many questions remain regarding the cognitive processes mediating the observed decline. Moreover, researchers have emphasized that future studies should investigate the degree to which automatic and efficient versus controlled and effortful processes are involved in various aspects of mental state understanding (Apperly, Samson, & Humphreys, 2005; Surtees & Apperly, 2012). Although a variety of instruments have been utilized to examine mental state understanding during aging, typically, the tasks involve explicit

cognitive reasoning. Given the robust finding of age-related decline in mental state understanding, older adults are an ideal sample to investigate the hypothesis that cognitively efficient processes are involved in level-1 visual perspective taking. In other words, since aging is associated with declining cognitive processes, an older adult sample provides a useful test group for examining cognitively efficient processes. If older adults show evidence of retaining cognitively efficient processes in spite of the cognitive decline typically associated with aging, then this would provide evidence that efficient processes are involved in some aspects of mental state understanding.

Research suggests that individual differences in mental state understanding are associated with social competence such as, solving social problems, communication skills, and moral reasoning (Couture, Granholm, & Fish, 2011; Dunn, 1996; Liddle & Nettle, 2006; Young, Cushman, Hauser, & Saxe, 2007). Moreover, when individuals suffer from impairments in mental state understanding their ability to socially interact is substantially reduced (e.g., Krych-Applebaum et al., 2007; Pollice et al., 2002). During aging, there is evidence to suggest that theory of mind deficits are related to reduced participation in social activities (Bailey, Henry, & von Hipple, 2008). Considering that the ability to make mental state attributions is related to social functioning, and older adults show moderate to large deficits compared to young adult samples (Henry et al., 2012), it follows that investigating the mechanisms underlying age-related declines may have important implications. In a recent review of mental state understanding in aging, Moran (2013) emphasized that future research should seek to unravel the degree to which general cognitive resources impact the observed impairments. With the goal of improving social understanding for older adults, Moran suggested that it is essential to

know where remediation efforts should be devoted. That is, elucidating which cognitive processes influence age-related deficits in mental state understanding may have important implications for improving social skills during aging. Considering the consequences of suffering a reduced capacity for mental state understanding, I believe it is a worthwhile endeavor to investigate the underlying cognitive mechanisms of age-related decline during aging.

Purpose and Research Questions

The purpose of the current study was to explore mental state understanding during aging utilizing two tasks that vary in the degree to which they involve cognitively efficient versus effortful processes. A dual-task involving level-1 visual perspective taking and a secondary executive functioning task were used to examine cognitively efficient processes. A theory of mind story task was used to examine cognitively effortful processes. The primary objective was to investigate if there is evidence of cognitively efficient processes in level-1 visual perspective taking in an older adult sample. To undertake this first goal, a dual task was utilized to examine if older adults show altercentric interference (i.e., slower and more error prone when asked to judge one's own perspective when the other perspective is inconsistent) when concurrently performing a secondary executive functioning task. To be precise, if older adults show evidence of calculating the agent's perspective during dual-task trials, then this would suggest that cognitively efficient processes are involved in visual perspective taking (i.e., a concurrently performed secondary executive function task does not disrupt the calculation of the agent's perspective). The secondary goal of the current study was to examine the contributions of verbal and spatial working memory in a level-1 visual

perspective taking task as well as a theory of mind story task. Specifically, the current study investigated the following questions:

QI   Is there evidence of cognitively efficient processes in level-1 visual perspective taking in an older adult sample?

Q2   In an older adult sample, how does verbal and spatial working memory contribute to theory of mind?

Q3   In an older adult sample, how does verbal and spatial working memory contribute to level-1 visual perspective taking?

Glossary of terms

Age-related general cognitive decline - A suite of mental capacities associated with decreasing performance during the aging process.

Altercentric effect - Cognitive interference that occurs when knowing the perspective of another individual hinders making a judgment regarding one's own perspective (i.e., two perspectives are inconsistent, which results in an interference effect for the judgment of self perspective).

Dual task - A neuropsychological measure that includes the combination of two tasks that must be performed concurrently.

Egocentric effect - Cognitive interference that occurs when self perspective hinders making a judgment regarding another individual's perspective (i.e., two perspectives are inconsistent, which results in an interference effect for the judgment of the other individual's perspective).

Executive functioning - Higher order cognitive processes including planning, inhibition control, and mental flexibility. Some authors consider working memory as a component process of executive functioning; however, in the current study I am considering working memory separately. Executive functioning is operationalized in this study by an

inhibition task in which participants were asked to respond to an auditory presentation of the words "day" or "night" by responding in the opposite direction of the words. That is, when participants hear the word "day" the correct response was to press a picture of a "moon" on a computer mouse; when they hear the word "night" the correct response was to press a picture of a "sun".

Level-1 perspective taking - The ability to visually track what another individual can or cannot see.

Mental state understanding - This term is used broadly to capture the human ability to perceive, encode, and reason about mental states such as, beliefs, desires, emotions, intentions, and visual perspectives of others. The cognitive mechanisms involved in mental state understanding have been argued to include both cognitively efficient (i.e., implicit) and effortful (i.e., explicit) processes.

Spatial working memory - The mental capacity for the storage, manipulation, and processing of spatial information.

Theory of mind - The ability to make mental state inferences in order to predict behavior

Theory of mind story task - A task in which participants read short vignettes including two or more characters followed by questions that ask the participants to make mental state inferences regarding the characters in the story. This task has been demonstrated to involve explicit cognitive processes such as, executive functioning, working memory, and verbal reasoning.

Working memory - The cognitive capacity that includes the storage, manipulation, and processing of information; researchers often consider working memory as a component

(i.e., subprocess) of executive functioning, however, for this study, working memory was considered separately from executive functioning.

Verbal working memory - The mental capacity for the storage, manipulation, and processing of verbal information.

CHAPTER II

REVIEW OF LITERATURE

Studies examining age-related changes in mental state understanding have

primarily utilized theory of mind tasks, which require a relatively high degree of explicit

cognitive resources. Research using several different types of theory of mind tasks, (e.g.,

stories and videos), suggests that mental state understanding declines during aging;

however, several cognitive capacities decline during aging that are also related to

individual differences in mental state understanding. Given that theory of mind abilities

have been shown to be associated with executive functioning (e.g., Duval, Piolino,

Bejanin, Eustach, & Desgranges, 2011; Saltzman, Strauss, Hunter, & Archibald, 2000),

working memory (e.g., Mutter, Alcorn, & Welsh, 2006), and verbal ability (e.g., Dunn &

Brophy, 2005; Milligan, Astington, & Dack, 2007), researchers have investigated if age-

related changes in theory of mind may be due to more general cognitive decline. The

literature up to the present time, however, is unclear regarding the specific role of general

cognitive decline on age-related theory of mind deficits.

Contrary to the explicit cognitive processes involved in theory of mind tasks,

some aspects of mental state understanding have been suggested to include cognitively

efficient processing (Samson, Braithwaite, Andrews, & Bodley Scott, 2010). For

example, evidence suggests that level-1 visual perspective taking, which includes being

able to track the visual perspective of another individual (Sodian, Thoermer, & Metz,

2007), may proceed relatively efficiently (Qureshi et al., 2012). Accordingly, some researchers have argued that a full account of mental state understanding includes both cognitively effortful and cognitively efficient processes (Frith & Frith, 2008). In line with the evidence that some aspects of mental state understanding operates efficiently while explicit mental state understanding involves cognitively demanding processes, Apperly and Butterfill (2009) proposed that two systems underlie mental state understanding. In their model, one system is characterized as implicit and includes automatic processes. Apperly and Butterfill propose that a second system, which operates in parallel with the implicit system, is more flexible and requires explicit processing. Therefore, the two systems are considered to involve cognitively efficient and cognitively effortful processes respectively.

The inclusion of automatic and controlled processes in social cognition has been discussed in a wide range of social psychological topics (Chaiken & Trope, 1999; Lieberman, 2007; Smith & DeCoster, 1999). Several authors have specifically proposed that mental state understanding is driven by two systems (Leslie, German, & Polizzi, 2005; Leslie & Thaiss, 1992; Tager-Flushberg & Sullivaan, 2000). The dual route as conceptualized by Apperly and Butterfill (2009) offers several specific theoretical points. First, the cognitively efficient system comes at a price of being inflexible whereas the effortful system is flexible and can process complex information. Second, Apperly (2010, 2013) argues that the cognitively efficient system must be constrained by limits and understanding the nature of these limits will be useful for advancing the dual route model. Third, this framework accommodates evidence that suggests infants are capable of implicit false belief understanding (e.g., Onishi & Baillargeon, 2005; Surian, Caldi, &

Sperber, 2007) even though children do not pass explicit false belief tasks until between the ages of three or four years old (Wellman, Cross, & Watson, 2001). In a false belief paradigm (Wimmer & Perner, 1983) children observe an object being hidden in a location, which is also observed by another character. Subsequently, the character leaves the room and the object is moved to a different location. To pass a false belief task, a child must explicitly demonstrate (i.e., give a verbal response) that the character holds a false-belief and that the false belief will motivate their behavior (e.g., where they will look for a toy, Baron-Cohen, Leslie, & Frith, 1985; Wimmer & Perner, 1983). After decades of research utilizing many variants of the false belief paradigm, researchers agree that children cannot pass this explicit false belief task until after the age of three (.g., Astington & Jenkins, 1999). However, using indirect measures (e.g., looking time), researchers have found evidence that infants obtain implicit awareness of false-beliefs (e.g., Clements & Perner, 1994; Southgate, Senju, & Csibra, 2007). Apperly and Butterfill's (2009) two-system framework provides a theoretical account for these seemingly contradictory bodies of literature. To date, no studies have investigated cognitively efficient mechanisms in mental state understanding in older adults. In light of the robust findings of age-related cognitive decline, it would be valuable to examine if there is evidence of cognitively efficient processes involved in mental state understanding during aging.

With the goal of examining the underlying cognitive processes of mental state understanding during aging, the current study used two tasks that differed in the degree to which they involve explicit cognitively mediated processes versus efficient processes. Namely, in addition to a theory of mind task, which requires cognitively effortful

processes, a level-1 visual perspective taking task was used to investigate efficient processes. Thus, as outlined in the previous chapter, the goal of the current study was two fold. First, to examine older adult performance on a level-1 visual perspective taking task with the purpose of investigating cognitively efficient processes in mental state understanding during aging. Additionally, to examine how verbal and spatial working memory contributes to the performance of these two tasks in an older adult sample.

The following literature review is organized into three broad sections for the following purposes: First, to provide a brief review of cognitive aging literature relevant to the current study. Second, offer an assessment of the literature to date examining mental state understanding during aging. Third, to present a description of the methods, results, and conclusions of three studies that used a level-1 visual perspective taking task. Ultimately, the goal of the current chapter is to draw together the research investigating mental state understanding in older adults as well as to present evidence that suggests some aspects of mental state understanding involve cognitive processes that proceed relatively efficiently. Finally, the current chapter will conclude with a summary and the hypotheses for the current study.

Cognitive Aging Related to Mental State Understanding

A substantial amount of research suggests that executive functioning (e.g., Hughes, 1998; Perner & Lang, 1999; Perner & Lang, 2000) and working memory capacity (Davis & Pratt, 1995; Hughes, 1998; Keenan, Olson, & Marini, 1998; Keenan, 1998) impacts the ability of preschool children being able to pass a false belief task independent of age and other abilities. For instance, a meta-analysis examining the relation between children's performance on executive functioning and false belief

understanding found a mean correlation coefficient of 1.08, indicating a strong effect for the relation between these abilities (Perner & Lang, 2000). In addition, several studies have found that individual differences in false belief performance are related to executive functioning (e.g., Bora, Eryavuz, Kayahan, Sungu, & Veznedaroglu, 2006; Bora, Sehitoglu, Aslier, Atabay, & Veznedaroglu, 2007) and working memory abilities (Lin et al., 2010) in young adult samples. Since normal aging is associated with declining mental capacities in several cognitive domains (Hedden & Gabrieli, 2004), researchers examining mental state understanding during aging must take into consideration age-related cognitive decline.

Normal Aging

Normal aging involves cognitive decline that is not considered to be associated with impairment of daily functioning (Salthouse, 2010). In contrast to normal aging, dementia is a set of global cognitive symptoms associated with significant dysfunction (McHugh & Folstein, 1977). Research suggests that for individuals 65 years old the prevalence of dementia is 4%, with rates doubling approximately every 5-6 years thereafter; thus, approximately 15% of all 80 year olds have some form of dementia (Prince et al., 2013). The purpose of the current study is to investigate mental state understanding during normal aging; therefore, the literature review that follows does not consider cognitive decline associated with dementia.

Despite the observed variability among individuals (Hultsch, MacDonald, & Dixon, 2002; Salthouse, 2010) and functions (Schaie, 2005), healthy aging is associated with cognitive decline after the age of 60 (Schaie, 1996; 2005). Accordingly, most of the studies examining older adult performance on mental state understanding tasks have

included adults over 60 years old (e.g., German & Hehman, 2006). Three domains of cognitive aging are particularly relevant to the literature investigating mental state understanding during aging: processing speed, executive functioning, and working memory. The purpose of the following section is twofold: (a) to review three areas of cognitive aging relevant to mental state understanding; and (b) to outline areas of cognitive decline that could specifically impact the tasks in the current study.

Aging and Processing Speed

One of the most robust findings in the cognitive aging literature is that mental processing speed (i.e., speed of information processing) slows during the aging process (Bashore, 1989; Salthouse, 1985, 1996; Verhaegen & Cerella, 2008). While there are a variety of methods used to measure processing speed, reaction time is one of the most frequently used in cognitive aging studies (Chen & Li, 2008). Using reaction time as a dependent variable, slowed mental processing is indicated by slower reaction times on a variety of tasks for older compared to young adults. For example, many cognitive aging studies examine young compared to older adult's reaction times on simple reaction time tasks (e.g., Earles & Salthouse, 1995). Specifically, a visual stimulus is presented and participants must respond with a button press on a computer as soon as they see the stimulus. Another commonly used task in older adult studies are choice reaction time tasks. Participants are required to make a selection from two or more different choices of stimuli as quickly as possible, which are presented randomly (e.g., Der & Deary, 2006).

In addition to reaction time as a measure of processing speed, researchers also use reaction time as a dependent variable to examine attention (Tse, Balota, Yap, Duchek, & McCabe, 2010), perception (Ben-David & Schneider, 2009), language processing (Caza

& Moscovitch, 2005), memory (Kumar, Rakitin, Nambisan, Habeck, & Stern, 2008), and executive functioning (Chen & Li, 2008). For instance, an in-depth analysis of reaction time distributions was used to investigate attention in older adults (Tse et al., 2010). In particular, cognitive researchers often use reaction time as a dependent measure for experimental designs where independent variables are manipulated and the effects of the various conditions are investigated by way of examining differential response times for the conditions (Deary, Liewald, & Nissan, 2011).

A common finding in reaction time studies is that older adult samples demonstrate greater reaction time variance compared to young adult samples. Often, the standard deviation in older adults has been reported to be 1.5 times greater compared to young adults (Ratcliff, Spieler, & McKoon, 2000). In addition to the larger variability across individuals, there is also greater within person inconsistency compared to younger adult samples (Fozard, Vercruyssen, Reynolds, Hancock, & Quilter, 1994; Williams, Strauss, Hultsch, & Hunter, 2007; Anstey, 1999; Hultsch et al., 2002). The degree to which older adults demonstrate inconsistent performance has been shown to depend on the type of task (West, Murphy, Armilio, Craik, & Stuss, 2002) and the relative speed of individuals. Williams, Hultsch, Strauss, Hunter, and Tannock (2005) found that older adults with fast reaction times were more consistent compared to those individuals falling in the right hand tail of the distribution. Overall, moment-to-moment inconsistency is observed to be greatest in individuals with the slowest reaction times. Even though variability both between and within individuals tends to increase with age (Hultsch, MacDonald, & Dixon, 2002), studies using reaction time continue to be a common approach to investigate research questions using a variety of tasks in aging samples.

Although reaction latencies are overall slower in older compared to younger adults, some domains show differential age-related slowing (Cerella, 1985; Verhaegen, & Cerella, 2008). For instance, using meta-analytic techniques, Lima, Hale, and Myerson (1991) found that older adults demonstrate less slowing than younger adults in tasks using verbal compared to nonverbal stimuli. That is, while reaction time using both verbal and nonverbal stimuli decline across age, older adults perform significantly slower on nonverbal tasks (i.e., nonlexical tasks) compared to verbal tasks (i.e., lexical tasks). In particular, processing speed has been found to be especially impaired in older adults on tasks involving spatial information (e.g., Tomer & Cunningham, 1993; Babcock, Laguna, & Roesch, 1997). Even though evidence suggests that age-related slowing in processing speed varies based on the type of domain (e.g., lexical, spatial, arithmetic, perceptual), evidence overwhelmingly suggests that cognitive slowing occurs across all tasks with age (Bashore, van der Molen, Ridderinkhof, & Wylie, 1997; Madden, 1989; Myerson, Wagstaff, & Hale, 1994; Perfect, 1994; Schultz, 1994).

Aging and Executive Functioning

Many researchers consider executive functioning to include a suite of high-level cognitive processes consisting of inhibition control, planning, and mental flexibility (Chan, Shum, Toulopoulou, & Chen, 2008; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Suchy, 2009); however, researchers are not in complete agreement regarding how executive functioning should be defined and measured (Alvarez & Emory, 2006; Jurado & Rosselli, 2007; Miyake, Emerson, & Friedman, 2000; Welsh, 2002). Since cognitive aging researchers suffer the challenge of agreeing upon how executive functioning should be operationalized, there is wide disagreement regarding which tasks

best conceptualize executive function decline in older adults. Furthermore, fundamental questions are debated (Daniels, Toth, & Jacoby, 2006) such as whether or not age-associated deficits in executive functioning can be explained by one central ability that declines during aging or, alternatively, if distinct executive components such as, inhibition control versus task shifting, are differentially impaired (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Nonetheless, overall there is substantial evidence that older adults perform worse than younger adults on executive functioning tasks, in particular for inhibition and mental flexibility (e.g., DiGirolamo et al., 2001; Kramer, Hahn, & Gopher, 1999; Wecker, Kramer, Wisniewski, Delis, & Kaplan, 2000). While acknowledging that the debate is far from settled regarding whether age-related executive functioning decline should be considered through a unified or component specific lens (Daniels, Toth, & Jacoby, 2006), evidence suggests that executive functioning decline begins as early as the third decade (Salthouse, 2009a).

A recent meta-analytic investigation of aging and executive function examined three aspects of executive control: (a) inhibition control (i.e., resistance to interference); (b) coordinative ability; and (c) task shifting (Verhaeghen, 2011). The ability to coordinate was assessed through studies using dual-task designs, which showed a small but reliable age effect (Verhaeghen, Steitz, Sliwinski, & Cerella, 2003; Verhaeghen & Cerella, 2002). The most reliable decline was found for coordinative ability and task shifting (i.e., divided attention and the maintenance of two different mental task sets). One of the tasks that I used in the current study utilized a dual-task design, thus, the evidence that coordinative ability and task shifting shows reliable age-related decline is particularly relevant to the current study.

One aspect that typically is agreed upon is that executive functioning consists of effortful processes that guide behavior (Banich, 2009). Since I am interested in examining cognitively effortful versus efficient mechanisms in mental state understanding, the evidence of age-related decline in executive functioning has important implications for the current study. Namely, I used a dual task; previous research suggests that compared to young adults, older adults suffer disproportionate dual task impairments. The implications of the dual task on older adult performance for the current study are considered later in this chapter.

Aging and Working Memory

A substantial amount of research suggests that measures of working memory (i.e., the storage, manipulation, and processing of information, (Baddeley, 1986; Miller, Galanter, & Pribram, 1960) decline across the lifespan and that various components of working memory show differential decline (e.g., Jenkins, Myerson, Joerding, & Hale, 2000). Myerson, Emery, White and Hale (2003) conducted a cross-sectional analysis of the normative data from the Wechsler Memory Scale (WMS-III) and found evidence of differential decline between tasks. A negative linear slope was found for both spatial and digit span scores with the former demonstrating significantly more decline than the latter; whereas, a curvilinear pattern was found for number sequencing. The authors concluded that these patterns are suggestive of at least two possible mechanisms involved in age-related memory changes. Specifically, the linear decline maybe associated with mechanisms related to the storage of information, whereas the curvilinear decline maybe associated with mechanisms related to executive control aspects of working memory (i.e.,

both storage and processing), which decrease disproportionately with age (Myerson et al., 2003).

Collectively, evidence suggests that complex span tasks, which require maintenance and processing, show greater age decline compared to simple span tasks, which requires maintenance only. For instance, Wingfield, Stine, Lahar, and Aberdeen, (1988) held the type of memory items consistent when comparing complex versus simple span task performance; results indicated an age-related deficit for complex but not simple span tasks. A meta-analysis found simple span tasks demonstrated moderate age-related decline (forward digit span, d= -.53) whereas, complex span tasks demonstrated large age-related declines (d= -1.01 and -1.54, sentence span and listening span, respectively, Bopp & Verhaeghen, 2005).

Thus far, I have reviewed three domains of age-related cognitive decline that have been found to be associated with performance declines in mental state understanding during aging: processing speed, executive functioning, and working memory. One of my primary goals in the section that follows is to explore the degree to which these cognitive processes may mediate the performance of mental state understanding in older adult samples.

Mental State Understanding in Older Adults

The studies to date examining mental state understanding during aging have primarily used theory of mind tasks, which, in varying degrees, involve explicit cognitive processes. For instance, several studies have used theory of mind story tasks in which participants read a vignette of two characters interacting and are asked to make an inference regarding one of the character's mental states (e.g., Maylor, Moulson, Muncer,

& Taylor, 2002). Another example involves second order theory of mind tasks, which assess recursive reasoning about embedded mental states. That is, a second order task requires that participants make inferences about a person's mental state about another individual's mental state (e.g., what Al thinks Susan thinks). Although the first study examining older adult theory of mind abilities did not find evidence of age-related decline (Happé, Winner, & Brownell, 1998), subsequent studies suggest that theory of mind performance does decline with advancing ages (e.g., Slessor, Phillips, & Bull, 2007; Sullivan & Ruffman, 2004). When reviewing the literature it is important to consider that the reduced performance of older adults relative to young adults may be due to age-related deficits in processing speed, executive function, and working memory that I reviewed in the first section of the current chapter. Several studies (e.g., German & Hehman, 2006) have investigated this hypothesis; however, the evidence thus far, is somewhat mixed. That is, there is evidence to suggest that some theory of mind deficits are mediated by processing speed, executive functioning, and/or working memory (e.g., Phillips, Bull, Allen, Insch, Burr, & Ogg, 2011). There is also evidence to suggest that during aging, impairments in theory of mind tasks are independent of cognitive domains (e.g., Maylor et al., 2002).

The evidence that supports the latter hypothesis indicating theory of mind impairments cannot be fully explained by general cognitive decline corroborates with research suggesting a specific cognitive network is related to social functioning. The evidence that supports a neurocognitive architecture specific for social cognition comes primarily from two areas of research; one from patients with damage to the frontal lobes (e.g., Stone, Baron-Cohen, & Knight, 1998) and amygdala (e.g., Adolphs, Baron-Cohen,

& Tranel, 2002) and the other from the literature investigating autism spectrum disorders (e.g., Baron-Cohen, Leslie, & Frith, 1985; Frith, 2001). Both of these lines of research point to modularity in social cognition due to intact cognitive processes in the face of moderate to severe impairments in social functioning (Adolphs, 2002). This is not to say that age-related cognitive decline, especially in regards to executive functioning, does not negatively impact performance on mental state tasks. In fact, there is substantial evidence to suggest that age-related executive functioning impairment mediates mental state understanding decline in older adults. In the section that follows, I review the evidence that supports this hypothesis and conclude with my assessment of the evidence to date.

Mental State Understanding and
General Cognitive Decline

Apperly (2011) suggested that the role of executive processes might disproportionally impact older adults performance on explicit mental state understanding tasks. Indeed, evidence from several studies using a variety of tasks supports this assertion (Duval, Piolino, Bejanin, Eustach, & Desgranges, 2011; Saltzman et al., 2000; McKinnon & Moscovitch, 2007; Slessor, Phillips, & Bull, 2007). German and Hehman (2006) examined the performance of young and old adults on four theory of mind stories that were developed with the intention of systematically increasing the executive demands of each story. Two of the stories required either true-belief or false-belief reasoning; previous research suggests that false-belief reasoning requires greater inhibition control compared to true-belief reasoning (Leslie, German, & Polizzi, 2005; Leslie & Polizzi, 1998). The other two stories differed in terms of approach-desire or avoid-desire, with the latter requiring more executive resources compared to the former

(Cassidy, 1998). Performance declines were found for both young and older adults as the executive demands increased; however, older adults performed disproportionately worse compared to younger adults on the stories that have been purported to involve higher executive functioning demands.

Similar to findings with developmental samples, one component of executive functioning that has been implicated to impact theory of mind performance in older adults is inhibition control (German & Hehman, 2006). Bailey and Henry (2008) found that older adult performance on theory of mind tasks with high-inhibition demands showed significantly greater decline compared to theory of mind tasks with low-inhibition demands. Furthermore, a measure of cognitive inhibition (i.e., Stroop task) mediated theory of mind performance but measures of memory, mental flexibility, and processing speed did not. A series of hierarchical regression analyses conducted by German and Hehman (2006) indicated that older adult performance on the theory of mind story task was most strongly explained by processing speed and inhibitory control (measured by Stroop and Hayling's sentence completion). When reaction time was used as the dependent variable, inhibition was most strongly associated with theory of mind performance, whereas, speed of processing predicted the most variance in accuracy.

Charlton, Barrick, Markus, and Morris (2009) measured older adult performance on the Strange Story Task (SST, participants read a short vignette involving a character's mental state followed by a question regarding the mental state inference, Happé, 1994; Happé et al., 1998). In addition, eight tasks tapping various cognitive functions were administered (Digit Span Backward, Letter-Number Sequencing, Trail Making, Towers, Wisconsin Card Sorting, letter fluency, category fluency, and Stroop). SST performance

correlated with all neuropsychological tasks except for Towers and Letter-Number Sequencing. The Letter-Number Sequencing is considered a working memory task. Therefore, in this study older adult working memory performance did not correlate with SST; however, measures of inhibition control did. Furthermore, the authors conducted a mediation analysis (McKinnon, Fairchild, & Fritz, 2007), which indicated that the relation between age and theory of mind decline was fully mediated by executive function, information processing speed, and performance intelligence and partially mediated by verbal intelligence.

There is also evidence that decline in mental state reasoning is partially mediated by working memory declines (Maylor et al., 2002; Phillips et al., 2011). For instance, several studies did not find any age effects on first-order theory of mind tasks (i.e., inferences about one character's mental states) but found that older adults performed worse than young adults on second-order theory of mind tasks (i.e., inferences about one person's mental state about another individual's mental state, Maylor et al., 2002; McKinnon & Moscovitch, 2007). Since second order theory of mind tasks impose a higher working memory load compared to first order tasks, these findings suggest that as working memory demands increase, older adults perform worse than young adults. In one study that found age-associated deficits on second order but not first order theory of mind story tasks, the authors analyzed the older adult error rates (McKinnon & Moscovitch, 2007). Results indicated that almost 70% of the errors were due to their failure of considering multiple pieces of information or differing information of two different characters in the stories.

Sullivan and Ruffman (2004) found that older adults (m= 73 years) performed worse than younger adults (m= 30 years) on a theory of mind story task; however, there was no longer a significant age effect when fluid intelligence (i.e., reasoning and problem solving skills, Cattell, 1963) was accounted for. Sullivan and Ruffman (2004) measured fluid intelligence with AH4 (Heim, 1970), which includes arithmetic, synonyms, verbal opposites, and analogies. Of note, several latent variable studies have found that working memory is closely associated with fluid intelligence (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999). That is, working memory has been shown to be the best predictor of fluid intelligence compared to other cognitive variables such as processing speed and short-term memory (Kane, Hambrick, & Conway, 2005). Thus, it is possible that working memory capacity partially mediated the relationship between fluid intelligence and theory of mind ability in this study.

The findings that executive functioning, particularly inhibition, and working memory partially mediates theory of mind performance in older adults are not surprising given the evidence that performance on theory of mind tasks are influenced by executive processes in children and young adult samples (e.g., Carlson, Moses, & Hix, 1998). Of course, even young adults show reduced performance on theory of mind tasks as executive processing demands increase (Lin et al., 2010; McKinnon & Moscovitch, 2007); however, since older adults perform worse on executive functioning tasks compared to young adult samples, one would expect that older adults would be disproportionally affected. Indeed, as reviewed earlier, results from several studies indicate that older adults perform disproportionally worse than young adults on mental

state tasks as executive demands increase (e.g., German & Hehman, 2006; McKinnon & Moscovitch, 2007).

Collectively, there is substantial evidence to suggest that age-related decline in mental state understanding is associated with general cognitive impairments. Based on my analysis of the literature, and in line with Kemp, Després, Sellal, and Dufour's (2012) review, the accumulation of research suggests that age-related deficits in making mental state attributions are at least partially mediated by processing speed, inhibitory control, and working memory decline. For instance, studies suggest that impairments increase disproportionately for older adults as secondary executive functioning task demands increase (e.g., McKinnon & Moscovitch, 2007; Riby, Perfect, & Stollery, 2004; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003). Furthermore, the findings that age-related deficits on second order but not first order theory of mind tasks suggests that older adults display impairments only as executive demands increase (Maylor et al., 2002; McKinnon & Moscovitch, 2007). In agreement with my analysis, Moran (2013) substantiated in his review that executive functioning and fluid intelligence, which he defines as including working memory and processing speed, explains some of the theory of mind impairments observed with age.

To date, the age-related decline in mental state understanding has been demonstrated through theory of mind measures, which require explicit cognitive resources (Henry et al.,, 2012). Given the strong evidence in support of age-related decline in theory of mind tasks, it is of interest to examine if some aspects of mental state understanding are preserved during the aging process. A candidate process that has been argued to involve cognitively efficient mechanisms is level-1 visual perspective taking

(Qureshi et al., 2010). The purpose of the next section is to consider level-1 visual perspective taking that has been suggested to involve cognitively efficient processes related mental state understanding. In the section that follows, a series of studies are reviewed that investigated level-1 visual perspective taking in young adults and children.

<div align="center">**Level-1 Visual Perspective Taking**</div>

**Evidence of a Cognitively Efficient
System in Perspective Taking**

Samson, Apperly, Braithwaite, Andrews, and Bodley Scott (2010) were interested in investigating if adults automatically process another persons' perspective in certain situations. In an experimental research design, participants made quick judgments on a level-1 perspective taking task. Participants viewed a picture of a room with an agent (i.e., computer-generated graphic of a person) standing facing a wall with red dots displayed on the walls.   In some conditions, the agent could "see" the same number of red dots as the participant. In other conditions, the red dots were behind the agent and thus, the number of dots the agent and the participant could see did not match (Figure 1).
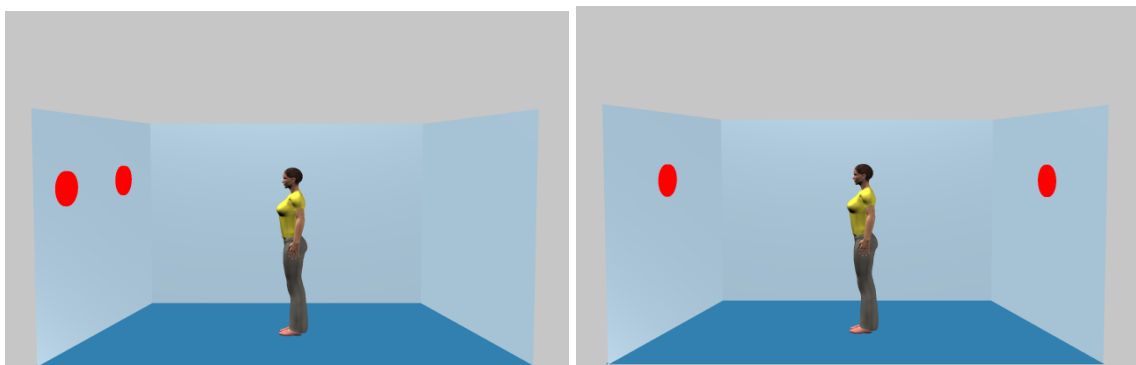
Figure 1 A   Figure 1 B

Figure. 1. Examples of Stimuli Presented in Samson et al. (2010). A) Participants and the agent had the same perspective of the dots (consistent conditions); B) Participants saw a different number of dots than the agent (inconsistent conditions).

After each trial, participants were asked to judge either, (a) how many dots they could see (self perspective), or (b) how many dots the agent could see (other perspective). In the first experiment, trials asking participants to judge either self or other perspectives were presented in random order within the same block. The second experiment separated the type of questions being asked of the participants (i.e., self or the agent's perspective) into distinct blocks; that is, one block only asked participants to judge one's own perspective and a separate block only asked participants to judge the agent's perspective. In the third experiment, participants completed blocks with only self perspective trials (i.e., they never judged the agent's perspective). Additionally, the third experiment added a control condition in which a rectangle-distractor (i.e., nonsocial condition) was used in place of the computer-generated figure (i.e., social condition).

As predicted, egocentric interference effects were found; that is, participants were slower and more error prone in inconsistent compared to consistent conditions when they were asked to judge the agent's perspective. The surprising finding was that when participants were asked to judge their own perspective they were slower and more error prone in inconsistent compared to consistent conditions. This indicated that participants did not ignore the agent's perspective when being asked to judge how many dots they could see. Particularly noteworthy, these altercentric effects were also found in the second and third experiments indicating participants calculated the agent's perspective even under conditions when they were never asked to do so. No altercentric effects were found for the nonsocial condition (i.e., the rectangle), which indicated that the interference effects found in the social conditions were not likely due to the configuration of the space but instead were associated with intrusions from the agent's perspective.

The egocentric bias found in Samson et al. is in accord with other research suggesting egocentric biases (e.g., Birch & Bloom, 2007; Epley, Keysar, Van Boven, & Gilovich, 2004; Mitchell, Robinson, Isaacs, & Nye, 1996), which impacts judgments regarding someone else's perspective when it is different from our own. The novel finding in this study was the evidence that participants are also prone to altercentric biases, which impacts their subsequent judgments of what they can see (i.e., participants are slower and make more errors when the agent's perspective differs from their own). This was the case even when participants were only instructed to answer what they could see. The altercentric effect suggests that even when there was no reason for participants to judge the agent's perspective, which was the case in the third experiment, participants still spontaneously processed the agent's perspective.

Previous research suggests that cognitively effortful processes are necessary to overcome egocentric biases (Epley & Gilovich, 2004; Epley, Morewedge, & Keysar, 2004; Keysar, Barr, & Horton, 1998; Nickerson, 1999). When considering the results from Samson et al. in addition to previous findings, it seems plausible that adjusting away from both egocentric and altercentric biases is cognitively effortful. The largest effect found in Samson et al.'s study was for egocentric biases, suggesting that making judgments regarding someone else's perspective when it is different from our own requires more cognitive effort compared to when making judgments regarding one's own perspective when it is different from another. That is, this finding suggests that an egocentric bias requires more effort to inhibit compared to an altercentric bias. In sum, Samson et al.'s (2010) results provided two important pieces of evidence. First, this was the first study to find an altercentric effect, which suggests that adults process at least

some aspects of other peoples' perspective automatically. Additionally, results indicated that in order to perform less egocentrically and altercentrically on perspective taking tasks, cognitive resources are recruited in order to inhibit the automatic processing. These conclusions are strengthened by the following two studies.

Surtees and Apperly (2012) found both egocentric and altercentric effects using a similar visual-1 perspective taking task in a sample of children (6-10 years old) and adults. In this study, the social condition used an agent depicted by a cartoon figure and the nonsocial conditions used yellow and blue rectangular-shaped sticks in replace of the agent. Also, instead of reading sentences, the participants heard the instructions as to which perspective to judge. Although adults performed better overall than the children (i.e., faster), the size of the interference effects were the same for both children and adults. That is, both samples demonstrated significantly slower reaction times for inconsistent compared to consistent trials when judging the other perspective (i.e., egocentric effect) as well as their own perspectives (i.e., altercentric effect). This was the first study that used the same perspective taking task for both children and adult samples. Even though adults performed overall better, the adults demonstrated the same interference effects as the children. These results suggest that dealing with inconsistent perspectives is cognitively effortful in development as well as adulthood. Additionally, results indicted that compared to the social condition the nonsocial condition did not reveal an altercentric effect signifying that participants only spontaneously judged the other perspective when the stimuli were social in nature. This finding suggests that the altercentric interference is a result of participants engaging in perspective taking versus a consequence of the spatial configuration of the task.

Qureshi, Apperly, and Samson (2010) suggested that the level-1 perspective task includes calculation and selection. That is, participants are calculating both their own perspective in addition to the agent's perspective and then subsequently selecting the relevant perspective (i.e., the agent's or self) based on the given probe. Based on this analysis, Qureshi and colleagues noted that if executive functioning resources are necessary for this task, then it is unclear if they are involved in calculation, selection, or both. Qureshi et al. (2010) devised the first study to investigate whether executive function resources are specifically involved in selection but not calculation.

Using a dual-task design, Qureshi et al. (2010) had participants perform an executive function task (i.e., Luria's tapping task) in conjunction with the same level-1 perspective-taking task as in Samson et al. (2010). Luria's tapping task (Luria, 1966) requires that participants listen to a recording of one or two tones and respond in opposition to what they heard (i.e., one key press if they heard two tones and vice versa). This inhibition task was used with the goal of examining the impact of executive functioning on selection and calculation processes with the following reasoning:

(a) In regards to calculation, if executive functioning processes are required to calculate the agent's perspective when it is irrelevant to the task (such as in the case when self perspective is required in inconsistent trials), then the secondary task should interrupt this calculation, therefore reducing altercentric effects.

(b) In regards to selection, if executive functioning is required for selection of perspectives in level-1 perspective taking (i.e., the primary task), then the dual-task trials (i.e. with the secondary executive functioning task), should result in a greater processing costs for both consistent and inconsistent trials but should disproportionately affect the

inconsistent trials. This reasoning is based on evidence from Samson et al., which found participants made more errors and were slower when perspectives were inconsistent compared to consistent. See Table 1 for a summary of the predictions made by Qureshi et al. regarding the effects of the executive functioning task on calculation and selection during the perspective taking task.

Table 1

Qureshi et al.'s Predictions for the Effects of the Dual Task

	Role of executive function	
	Calculation	Selection
Self judgments	Decreased altercentric interference	Increased altercentric interference
Other judgments	*	Increased egocentric interference

Note. * Qureshi et al. did not discuss a hypothesis in their article for the effects of executive functioning for the conditions of Other judgments.

Results indicated that the dual-task trials resulted in larger processing costs compared to alone trials for both consistent and inconsistent perspectives; however, the dual-task trials produced disproportionately larger processing cost for the inconsistent conditions. Thus, the second hypothesis was supported (i.e., dual-task trials resulted in larger processing costs compared to alone trials), leading Qureshi et al. to conclude that executive functioning is required for selecting between the two perspectives. In other words, the secondary executive functioning task slowed participants to a greater extent when the perspectives were inconsistent due to the reduction of executive processes available when having to make a selection.

In contrast, the first hypothesis was not supported with results indicating a larger altercentric effect in dual task compared to alone trials (i.e., participants were slower and more error prone when judging their own perspective when the agent's perspective was inconsistent with their own). Therefore, the authors concluded that executive functioning is not required for calculation of the two perspectives. This conclusion rests on the assumption that if executive functioning was necessary for participants to calculate the other perspective when being asked to judge their own perspective, then the secondary executive task (i.e., dual-task trials) would have reduced the cognitive resources available, and thus, participants would be faster when judging their own perspective because they are no longer calculating the agent's perspective. Instead, results suggest that participants continued to calculate the agent's perspective even when engaged in a secondary executive task. The finding of a larger altercentric effect in the dual-task trials is particularly noteworthy because this suggests that calculation of perspective is automatic. That is, for inconsistent trials when participants were asked for one's own perspective, participants calculated the agent's perspective even when performing a concurrent executive functioning task and there was no reason for the participant to do so.

Qureshi et al. is the first study to investigate sub-processes involved in level-1 visual perspective taking. The results suggest that executive functioning capacities may be necessary for selection and not calculation. It is important to note that the secondary executive task used in dual-task trials involve reaction inhibition and thus, this study points to the role of inhibition during selection processes. That is, these results suggest that inhibition resources constrain selection but not calculation processes involved in level-1 visual perspective taking.

To summarize, these studies provided four important pieces of evidence. First, the altercentric interference suggests that participants automatically calculated the agent's perspective even when it was not relevant to the task. Second, these findings suggest that in order to perform less egocentrically and altercentrically on perspective taking tasks, cognitive resources are recruited in order to inhibit more automatic processing. Third, the results that both children and adults revealed the same interference effects suggest that the underlying cognitive processes involved in level-1 visual perspective taking in children do not change with development. To be precise, even though the overall processing is more efficient (i.e., faster), adults continue to process their own perspective (i.e., egocentric interference) when being asked to judge another agent's perspective and vice versa. Finally, the dual-task study suggests that inhibition processes involved in executive functioning play a role in selection but not calculation components of level-1 visual perspective taking. This last finding suggests that level-1 visual perspective taking involves cognitively efficient processes.

Notably, level-1 visual perspective taking has not been examined in older adults. The current study was the first to investigate if older adults are prone to altercentric interference effects. Moreover, the current study examined the impact of inhibition resources on level-1 visual perspective taking performance in an older adult sample. Finally, it was of particular interest to examine if there was also evidence of cognitively efficient processes in calculating the agent's perspective in an aging sample. Considering that older adults are disproportionately impaired on dual tasks and demonstrate declines in explicit mental state understanding tasks, if evidence is found in an older adult sample that calculating the agent's perspective involves efficient processes, then this would

provide further support for the argument of cognitively efficient processes being involved in certain aspects of mental state understanding.

Summary

Many of the studies examining mental state understanding during aging have used theory of mind story tasks in which participants read a passage regarding two characters and subsequently answer questions regarding the characters' mental states (e.g., Maylor et al., 2002). Other studies have used visual stimuli in which participants must infer the mental states from videos (e.g., Slessor, Phillips, & Bull, 2007), photos (e.g., the Eyes Test, Phillips, MacLean, & Allen, 2002), or cartoons (e.g., Saltzman, Strauss, Hunter, & Archibald, 2000). In 2012, a meta-analysis was published that examined theory of mind abilities in older adults. The analysis included 23 datasets from 21 studies (published and unpublished) and found older adults (with a mean age of 65 years or older) performed worse compared to young adults on theory of mind tasks with an average effect size of -.36 (Henry et al.,, 2012). This negative effect size indicates that aging is associated with a moderate decline in theory of mind abilities.

In addition to age-related declines in theory of mind tasks, however, an extensive body of research indicates that older adults are impaired relative to young adults in many cognitive domains. Given that theory of mind has been shown to be associated with executive functioning and working memory in both developmental (e.g., Mutter, Alcorn, & Welsh, 2006; Sabbagh et al., 2006) and adult samples (e.g., Lin et al., 2010; Newton, & de Villiers, 2007), researchers have examined the contribution of these cognitive functions on theory of mind performance during aging. Currently, there is evidence to suggest that processing speed, executive functioning, and working memory mediates

some of the observed decline during aging (e.g., Rakoczy, Harder-Kasten, & Sturm, 2011). More research is needed to unravel which specific aspects of general cognitive decline impact mental state understanding during aging. Furthermore, it is unclear if some aspects of mental state understanding remain unimpaired during the aging process. Compared to theory of mind tasks, level-1 perspective taking may remain relatively intact during aging.

Hypotheses

In terms of level-1 visual perspective taking, I expect older adults to show both egocentric and altercentric interference effects. These interference effects would be demonstrated if older adults are significantly faster on consistent (i.e., matching) compared to inconsistent (i.e., not matching) conditions. Specifically, I expect older adults to show interference effects when being asked to judge another perspective (egocentric effect) and when being asked to judge self perspective (altercentric effect).

In regards to the dual-task trials, the rationale for the current study follows that presented by Qureshi, Apperly, and Samson (2010). Firstly, the effect of dual-task trials on *selection* processes during the level-1 perspective taking was examined. If executive functioning is necessary for participants to select the relevant perspective, then dual-task trials should result in larger processing costs for both consistent and inconsistent conditions with disproportionately large processing costs for inconsistent conditions. Secondly, the influence of the dual task on *calculation* of perspective was examined. If the agent's perspective was not calculated automatically but instead relies on executive processes, then inconsistent dual-task trials should result in a reduction of altercentric interference compared to inconsistent alone trials. That is, participants would respond

faster in the dual-task inconsistent trials when self perspective was required because they no longer calculated the agent's perspective. In contrast, if the agent's perspective was calculated automatically during inconsistent trials, then the secondary task should increase the altercentric interference. In accord with Qureshi et al.'s findings, I expected the latter outcome. In other words, dual-task trials should result in an increased altercentric effect for older adults, demonstrating that participants automatically calculate the agent's perspective.

In summary, my research questions and hypotheses are as follows:

QI   Is there evidence of cognitively efficient processes in level-1 visual perspective taking in an older adult sample?

H1   Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when being asked to judge *other perspective* on the level-1 perspective taking task (i.e., indicating egocentric bias).

H2   Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when being asked to judge *self perspective* on the level-1 perspective taking task (i.e., indicating altercentric bias).

H3   In regards to examining whether executive function is involved in selection processes, the dual-task trials will result in larger processing costs in consistent and inconsistent trials with disproportionately larger costs in the inconsistent trials for older adults.

H4   In regards to examining whether executive function is involved in calculation processes, dual-task trials will result in a significantly larger altercentric effect for older adults compared to alone trials. If this result is confirmed, then this would suggest that calculation of the other perspective does not rely on executive function processes.

Q2   In an older adult sample, how does verbal and spatial working memory contribute to theory of mind?

H5   Verbal working memory will make a stronger contribution to performance on a theory of mind story task compared to spatial working memory.

Q3   In an older adult sample, how does verbal and spatial working memory
          contribute to level-1 visual perspective taking?

H6   Spatial working memory will make a stronger contribution to performance
          on a level-1 visual perspective taking task compared verbal working
          memory.

In the section that follows, the method for the current study is described including

participants, sample size, instruments, and procedures. Finally, the statistical analyses

that were used to test the aforementioned hypotheses are described.

CHAPTER III

METHOD

The current study employs both experimental and correlational research designs. The population of interest is older adults with the goal of investigating performance on several tasks using a within subjects research design. University of Northern Colorado's (UNC) institutional review board (IRB) reviewed and approved this study (see Appendix A for approval letter). The consent form can be seen in Appendices B. Two amendments were made to the original IRB application. The first amendment requested an extension of the sampling procedures to include an out-of-state sub-sample of participants. The second amendment was for two changes in instruments. These amendments were approved by the IRB (Appendix C).

Participants

Participants consisted of 42 older adults (23 female, 19 male) between the ages of 60 and 87 (m = 68.25 years, sd = 5.40). Male and female participants did not differ by age ($t(41) = -1.259$, $p = .215$). See Table 2 for a break down of gender by five-year age ranges. The sample was highly educated with a mean years of education of 16.18 (sd = 3.10); however, males had significantly more years of education compared to females ($t(41) = 2.06$, $p = .047$, $d = .64$). Seventy-four percent of the participants were retired and most of the participants were living with a significant other (79%). See Table 3 for a

summary of age, gender, and education demographics. Further details regarding the full

sample are included in Appendix D (see Appendix E for the demographics form).

Table 2

Gender of Participants Broken into Five-year Increments

Age	Males N	Females N	Total N
61-65	9	6	15
66-70	6	10	16
71-75	3	4	7
76-80	1	2	3
80+		1	1
Total	19	23	42

Table 3

Age, Gender, and Education for the Full Sample

	N	Mean	SD
Age			
Male	19	67.16	4.41
Female	23	69.196	6.02
Total	42	67.80	4.56
Education*			
Male	17	17.24	3.46
Female	21	15.27	2.51
Total	39	16.13	3.08

* Missing data for some participants on this demographic variable

During the level-1 visual perspective taking dual task, one participant decided not

to finish the testing block. Another participant had an error rate ranging from 29 to 83

percent incorrect responses on the dual task. These two participants were dropped from

the analysis involving the level-1 visual perspective taking task. This resulted in a

sample size of 40 (21 females and 19 males) with a mean age of 67.66 (sd = 4.54) for the

analysis of variance (ANOVA) that examined the level-1 visual perspective taking task.

The current study included only aging in place participants. Aging in place

consists of individuals living in one's own home during the aging process (McDonough

& Davitt, 2011). According to the 2001 United States Census, 95% of all individuals 65

years and older are living in place. In the current study, an aging in place sample was

obtained with the goal of attaining a sample representative of the larger population.

Sampling Procedures

Participants were recruited from two suburban regions: Colorado's Front Range

(N=28) and a city within an hour's drive of Phoenix Arizona (N= 14). Convenience

sampling methods were employed including snowball sampling. Approximately 120

emails were sent, which yielded an approximate response rate of 8 percent. The rest of

the sample was obtained through word of mouth. Recruiting procedures consisted of

asking individuals if they were interested in volunteering an hour and half of their time.

Participants were given a 10-dollar gift certificate as a token of appreciation.

Measures

Level-1 Perspective Taking

A Dell laptop computer running Windows 7 and DMDX software (Forster &

Forster, 2003) was used to present the stimuli for this task. Response time data were also

collected and recorded by DMDX. It is important to note that there is a long history of

using reaction time as a measure in aging samples (e.g., Galton, 1885; Koga & Morandt,

1923). While there are a variety of methods used to measure cognition, response time

continues to be one of the most frequently used dependent variables in cognitive aging

studies. Participants were seated at a table in their home where the laptop computer was

set up. The stimuli for this task can be viewed in Figure 2 and are based on Samson at al.

(2010).[1] After completing the consent process, both verbal and written instructions were

provided to the participants (see Appendix F for written instructions).
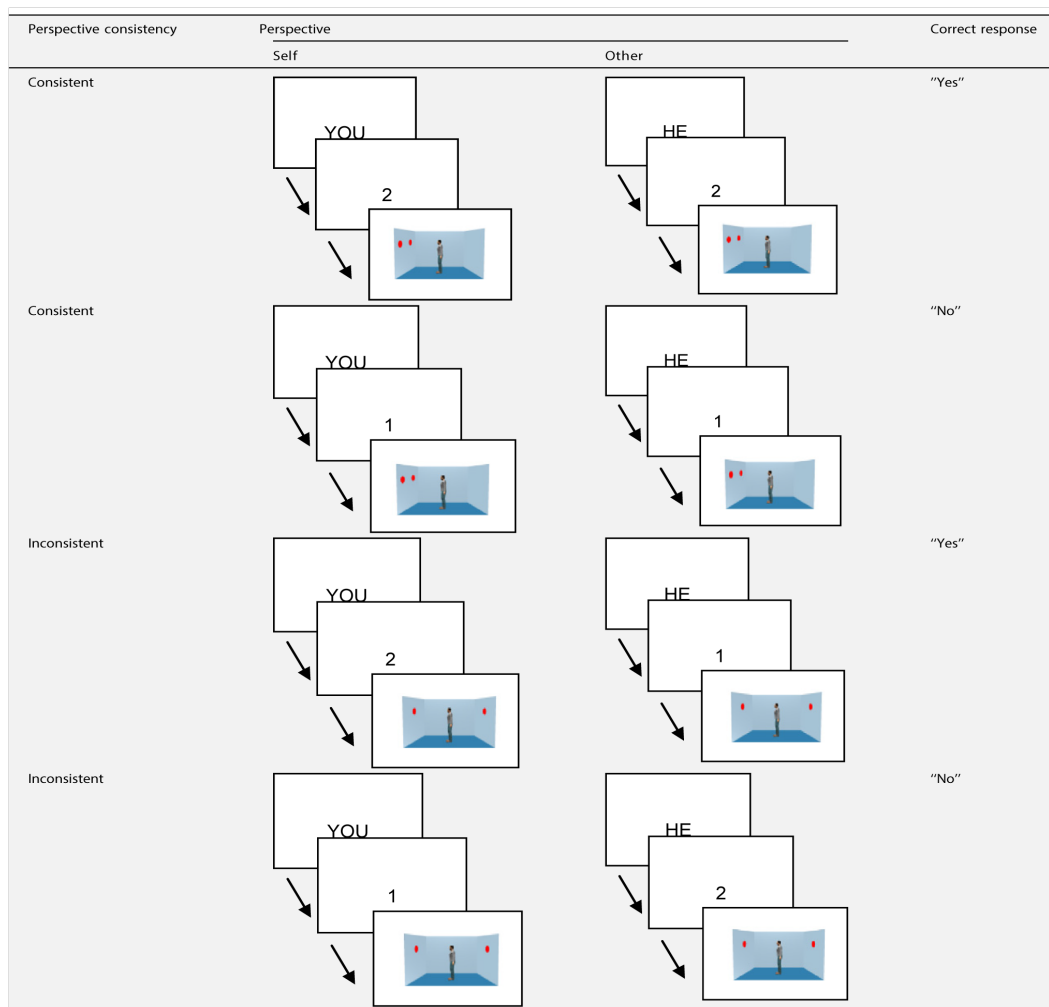
Figure. 2. Illustration of the Conditions for the Level-1 Visual Perspective Taking Task
Notes: This graphic was designed by Qureshi et al. The first frame indicates which
perspective (i.e., self or other) participants responded to; the second frame indicates the
number of dots participants verified; in the third frame participants made a response.

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[1]I am deeply grateful to Ian Apperly, Dana Samson, and Adam Qureshi who shared with
me all the files for this task including, instructions, stimuli and the programming code.

Each trial consisted of three stimuli that were presented on a computer screen. First, participants were presented with the words "YOU" or "HE/SHE" ("HE" for male participants and "SHE" for female participants). This first frame directed the participants to which perspective they were to respond to; "YOU" indicated to the participant to take their own perspective (i.e., self perspective) and "HE/SHE" indicated to the participant to take the agent's perspective (i.e., other perspective). In the second frame, the stimulus consisted of a number ranging from zero to three. Lastly, the third stimulus contained the prompt from which the participant was to respond. This final image per trial consisted of a picture of a room with the right, left, and back walls visible and varied by the number of red disks that were displayed on the walls. Red disks were displayed either on both right and left walls or just one of the walls (i.e., right and/or left). Some of the trials contained no red disks on the walls. In addition to the variation of red disks, a computer-generated agent (male for male participants and female for female participants) was displayed in the center of the room and faced either right or left walls. The participant's task was to indicate with a mouse press whether or not the number shown in the second frame matched the number of disks either they could see or the agent could see. That is, the participant's task was to indicate if the number presented to them in the second stimuli (i.e., zero, one, two, or three) matched the number of red dots that either they could see (i.e., the self condition) or the number of red dots that the agent could see (i.e., the other condition) in the final scene. A "yes" response was required when the picture matched the number of disks visible from the prompted perspective. A "no" response was required when the picture did not match the number of disks visible from the prompted

perspective. If no response was made after 4,000 ms, the trial timed out and the next trial began.

In summary, there were four possible conditions. In half the conditions participants were asked to judge their own perspective (self conditions; "YOU") and in the other half, participants were asked to judge the agent's perspective (other conditions; "HE/SHE"). Additionally, in some conditions the participant saw the same number of disks as the agent (consistent condition), and in other conditions the participant saw a different number of disks compared to the agent (inconsistent condition). That is, the consistency effect was testing for when the perspective of the participant was the same or different from the perspective of the agent. These experimental conditions produced two independent variables each with two levels for this task.   Following the analyses conducted by Qureshi et al. (2010) processing costs were calculated, which were produced by dividing the reaction time by the proportion of correct responses for this task. In addition to processing costs, reaction time was also used as a dependent variable.

Dual-task

This task was modeled after the dual-task presented in Qureshi et al. (2010), which consisted of a level-1 perspective taking task with a secondary inhibition task (see below). All aspects of the level-1 perspective taking task was identical to what was described above. That is, the task contained four possible conditions: self, other, consistent, and inconsistent conditions.

Secondary executive functioning task. The secondary executive functioning task required inhibitory control and was developed based on the inhibition demands of Luria's tapping task (Luria, 1966). Luria's tapping task consists of the presentation of

either one or two auditory tones. Participants are asked to press a key either one or two times, in a pattern that is incongruent with number of tones that they heard. In the current study, a variation of Luria's tapping task was implemented for the purpose of not confounding the numerical components of the level-1 visual perspective taking task (i.e., number of red disks) with the numerical aspect of the Luria's tapping task (i.e., number of tones). The inhibition task for the current study consisted of an auditory presentation of the words "day" and "night" instead of tones. Participants were asked to press either a picture of a moon or a picture of a sun on a computer mouse in a pattern that was incongruent with the words they heard. That is, if they heard "day", then they pressed the picture of a moon; if they heard "night", then they pressed the picture of the moon. A Macintosh laptop computer running OS X Lion and Superlab software (Cedrus, 2012) presented this task and recorded the response time data.

The stimuli used for the day-night task in the current study were modeled after a task designed to measure inhibition of response conflict in children (Gerstadt, Hong, & Diamond, 1994). In the child version of the Day-Night task, participants were shown a set of pictures with two different stimuli and were instructed to say "day" when they were shown cards with pictures of a moon on a black background and to say "night" when they were shown pictures of a sun on a white background. The version of the task used in the current study was chosen for the purpose of using auditory stimuli instead of visual stimuli.

Theory of Mind Story Task

A revised version of the Strange Story Task (SST, White, Hill, Happé, & Frith, 2009) was used as a measure of theory of mind. The SST consists of short stories; half

the stories contain mental state reasoning and the other half do not require mental state reasoning, which consist of the control stories. The theory of mind stories involves two characters in which one character has to make an inference regarding the other character's mental state (e.g., white lie, irony, and persuasion). The control stories contain information regarding a physical or mechanical outcome. There were 10 items for each subscale (i.e., theory of mind stories and control stories) for a total of 20 items. Participants were asked to answer two questions pertaining to the vignette; in the mental state stories, participants were required to make inferences regarding the mental state of one of the characters in the story; in the control stories, participants were required to answer questions relating to the physical story. Several studies (Castelli et al. 2010; Maylor et al., 2002; Sullivan & Ruffman, 2004) examining older adult theory of mind abilities have used variations of the SST.

Each correctly answered question received two points and partially correct answers received one point. This resulted with each item having a range of zero to two and the total maximum score for each subscale was 20. Scoring required subjective evaluation of participant answers; thus, inter-reliability was conducted. After two raters blindly scored the SST inter-rater was calculated; Cohen's kappa was .76. A third rater examined all discrepancies and made a decision regarding the score for each item until 100 percent agreement was reached. Previous research also reported Cohen's kappa of .76 for the SST (Kaland et al., 2005).

Working Memory

Although the structure of working memory demonstrates age invariance (Park et al., 2002), performance declines have been observed across the lifespan (e.g., Babcock &

Salthouse, 1990; Hale et al., 2011). Specifically, evidence from cognitive aging studies suggests there are differential age-related declines for spatial versus verbal working memory (Jenkins, Myerson, Joerding, & Hale, 2000; Hale et al., 2011). Furthermore, complex span tasks, which involve both storage and processing demands, demonstrate greater age-related decline compared to simple span tasks, which requires storage of information but not processing (Bopp & Verhaeghen, 2005). Thus, I have chosen to measure both verbal and spatial working memory using complex span tasks described below.

Verbal working memory. The Digit Span from the Wechsler Adult Intelligence Scale-IV (Wechsler, 2008) was used as a measure of verbal working memory. The Digit Span is comprised of three subscales: forward, backward, and sequencing. For the forward subscale, the researcher reads a series of numbers and the participant's task is to recall the numbers in the same order. For Digit Span backward, the participant's task is to recall the numbers in reverse order; for sequencing, the participant is to recall the numbers in ascending order. Each item consists of two trials that contain the same amount of numbers (e.g., item number one contains two trials each with two numbers and item number two contains two trials each with three numbers). The subscale is discontinued if the participant receives a score of zero on two consecutive trials within the same item. There are eight items per subscale with two trials per item. Either one or zero points are awarded for correct and incorrect trials respectively. The points are added to provide three subscale scores (with a maximum possible score of 16 points for each subscale) and a total score with a maximum possible score of 48. Previous research has found test-retest reliability for Digit Span has been reported to be .83 (Wechsler, 1997).

Spatial working memory. The Symbol Span subscale from the Wechsler's Memory Scale-IV (WMS-IV, Wechsler, 2009) was used as an estimate of spatial working memory. Symbol Span involves both storage and manipulation of visual details and has been designed to reduce verbal working memory and motor skills (Holdnack & Drozdick, 2009). The Symbol Span requires that participants visually examine shapes for 5 seconds from a flip chart held by the researcher. Immediately following the presented shapes, several more shapes are shown to the participant, some of which were previously shown. The participant's task is to indicate, in the correct order, which shapes they saw in the first set of stimuli (i.e., that were on the page from left to right). The researcher records the participants' exact responses and scores the task at a later time.

Two points are awarded if the participant correctly identifies the shapes in the correct order. One point is awarded if the participant correctly identifies the shapes but in the incorrect order. If the participant does not accurately identify all shapes, then zero points are awarded for that item. The points are added to provide a total score for this measure. If a participant scores a zero on four consecutive items, then the subscale is discontinued. The total Symbol Span consists of 26 items with a total possible score of 52. Reliability coefficients for Symbol Span have been reported to range from .72 for test-retest and .76 to .92 for internal consistency (Holdnack & Drozdick, 2009).

Demographics

Using a self-report questionnaire, demographic information was collected to describe the sample characteristics of the groups (see Appendix E; size 14 MS reference sans serif font was used). The demographic information consisted of age, gender, marital status, years of education, occupation, comfort with computers, perceived health status,

and level of physical activity. To measure level of physical activity, I used item number five from the Physical Activity Scale for Elderly Adults (Washburn, Smith, Jette, & Janney, 1993; PASE). This item asks participants "Over the past seven days, how often did you engage in strenuous sport and recreational activities such as jogging, cycling, swimming, singles tennis, aerobic dance, skiing, or other similar activities?" Response choices included: never, seldom (1-2 days), sometimes (3-4 days), and often (5-7 days). Previous research with older adult participants found that this item differentiated between exercisers and non-exercisers (Kirkland, Karlin, Babkes Stellino, & Pulos, 2010).

Procedures

At the beginning of each data collection session, the purpose of the study was explained and the consent process was completed. After the consent process, the computerized tasks were administered first, which included the level-1 visual perspective taking task conducted alone as well as the dual task version. Verbal instructions were provided and participants read instructions where it was emphasized to respond as quickly and as accurately as possible. Appendix F provides an example of the instructions (with the exception of the size and type of font; size 14 MS reference sans serif font was used). Following procedures previously conducted, (Qureshi et al., 2010; Surtees & Apperly, 2012), participants first completed practice blocks. Participants completed 26 practice trials (Qureshi et al., 2010) of the level-1 perspective taking task, 30 practice trials on the secondary inhibition task, and 52 practice trials of the dual-task (i.e., level-1 perspective taking and inhibition task). The practice trials took approximately 10 minutes to complete.

The test blocks consisted of 52 trials of the level-1 perspective taking (without the dual-task) and 52 dual-task trials (level-1 perspective taking with inhibition task performed simultaneously), which took approximately 15 minutes to complete. After a 5-minute break the SST, digit span, and symbol span tasks were administered. These final three tasks took between 40 and 60 minutes to complete and were counterbalanced across participants. In sum, the data collection time with participants, including consent and debriefing procedures, took approximately 90 minutes to complete. The following list represents a summary of the data collection procedure:

(a) Consent process

(b) Practice trials for level-1 perspective taking, inhibition task, and dual-task

(c) One block of the level-1 perspective taking alone with 52 trials

(d) One block of the dual-task condition with 52 trials

(e) Strange story task

(f) Digit span

(g) Symbol span

(h) Demographics

(i) Debriefing

Data Analysis

Data analysis was conducted using SPSS version 22. Preliminary data screening was conducted on all variables. Descriptive statistics including means, standard deviations, and minimum and maximum scores for each of the continuous variables were obtained. No errors were identified in the continuous variables. The demographic data were examined through case summaries; three errors were identified and corrected.

Histograms were produced to examine the frequency distributions for the continuous variables of level-1 visual perspective taking, theory of mind stories, verbal and spatial working memory. Consistent with reaction time data, the histograms showed strong positive skew for all variables included in the level-1 visual perspective taking task. Normality was further assessed by producing skewness and kurtosis statistics as well as Shapiro-Wilk test of significance. These distribution statistics were examined for each dependent variable (i.e., processing costs and reaction time) at each level of the independent variables for level-1 visual perspective taking. Significant positive skew was present for both processing costs and reaction time variables. A common method for reducing positive skew on reaction time variables is to calculate transformations on the skewed data (Osborne, 2002; Tabachnick & Fidell, 2001). Using this method, processing costs were transformed with the natural logarithm. For reaction time, the presence of outliers contributed to non-normality; thus, the data were winsorized by the upper 95th percentile (Wilcox, 1997, 2005). That is, all cases with scores above the 95th percentile were condensed down to the 95th percentile score. See Appendix G for processing costs and reaction time distribution statistics before and after the data were winsorized.

Scores for the theory of mind story task had negative skew. Three participants with scores more that 2.5 standard deviations below the mean contributed to this negative skew. The total subscale for verbal working memory (digit span forward, backward, and sequence) was normally distributed. When examining the verbal working memory subscales separately, digit span forward and backward had small deviations in normality. Verbal working memory as measured by digit span sequence was normally distributed. Spatial working memory as measured by symbol span was normally distributed.

Appendix H provides the distribution statistics for the theory of mind story task and verbal and spatial working memory. The following three sections reports the data analyses conducted for each of the research questions.

Examining Cognitive Efficiency

The first research question was, "Is there evidence of cognitively efficient processes in level-1 visual perspective taking in an older adult sample?" Two repeated measures analysis of variances (ANOVA) were conducted to test the first four hypotheses associated with this question (one with processing costs and one with reaction time as the dependent variable). As stated above, processing costs and reaction time distributions showed significant positive skew. To adjust for the non-normal distributions, processing costs were transformed by the natural log and reaction time variables were winsorized. Thus, the first ANOVA was conducted with a natural log transformation of processing costs as the dependent variable. The second ANOVA was conducted with reaction time winsorized as the dependent variable.

It is important to note that even though between and within person variance is greater in older compared to young adults (Hulsch, MacDonald, & Dixon, 2002), reaction time measures have been used successfully to estimate a wide-range of cognitive processes during the aging process. In the current study, the research questions and corresponding analyses with processing costs and reaction time as the dependent measures are investigated by a within subject design. Therefore, the repeated measure design accounts for individual differences in speed and manual dexterity.

The data analysis was modeled based on Qureshi et al.'s (2010) study. Only "yes" trials were analyzed because of the unbalanced number of answers of "yes" compared to

"no" trials. That is, due to the configuration of the dots, there were less mismatched "no" trials compared to matched "yes" trials. For both the alone and dual-task versions of the level-1 visual perspective taking, processing costs and reaction times were utilized as the dependent variables, which were calculated for each individual by condition. As previously discussed, the nature log transformation was conducted on processing costs and the reaction time data were winsorized by the top 95th percentile.

The factors that repeated for level-1 visual perspective taking were consistency (consistent versus inconsistent), perspective (self versus other), and task (alone versus dual). The consistency factor compared conditions when the perspective of the participant was either the same or different from the perspective of the agent. The perspective factor compared conditions when the participant was asked to take their own perspective (i.e., self) versus conditions where they were asked to take the agent's perspective (i.e., other). The level-1 perspective taking alone compared to the dual-task condition tested for a task effect. In total, the following conditions were entered into the ANOVA: a) Alone Other consistent; b) Alone Other Inconsistent; c) Alone Self Consistent; d) Alone Self Inconsistent; e) Dual Other consistent; f) Dual Other Inconsistent; g) Dual Self Consistent; and h) Dual Self Inconsistent.

Based on a power analysis conducted with G*Power 3.1 software (Faul, Erdfelder, Buchner, & Lang, 2009), a sample size of 38 was determined as necessary for a 2 x 2 x 2 repeated measures ANOVA with partial eta squared set at .33, alpha set at .05, and power set at .95. Table 4 provides a summary of the predicted outcomes for the ANOVA based on the hypotheses for the current study.

Table 4

Predicted Outcomes Based on a Repeated Measures ANOVA

Hypotheses	Hypothesis would be confirmed with the following results	Description
Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when being asked to judge *other perspective* on the level-1 perspective taking task (i.e., indicating **egocentric bias**)	Consistency effect (inconsistent > consistent for **other** perspective)	Participants show higher processing costs (i.e., are slower) on inconsistent compared to consistent trials when being asked to judge the agent's perspective
Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when being asked to judge *self perspective* on the level-1 perspective taking task (i.e., indicating **altercentric bias**)	Consistency effect (inconsistent > consistent for **self** perspective)	Participants show higher processing costs (i.e., are slower) on inconsistent compared to consistent trials when being asked to judge their own perspective
In regards to examining whether executive function is involved in *selection* processes, the dual-task trials will result in larger processing costs in consistent and inconsistent trials with disproportionately larger costs in the inconsistent trials for older adults	Interaction effect of: Task x Consistency (dual-task > alone for both inconsistent and consistent trials but sig. larger for inconsistent)	Participants show higher processing costs (i.e., are slower) on dual-task compared to alone trials for both consistent and inconsistent trials with significantly larger costs for the inconsistent trials
In regards to examining whether executive function is involved in *calculation* processes, dual-task trials will result in a significantly larger altercentric effect (i.e., slower RT's for inconsistent self trials) for older adults compared to alone trials	Interaction effect of: Consistency x Task (inconsistent > consistent for both dual-task and alone trials but sig. larger for dual condition)	Participants show a significantly larger altercentric interference effect (i.e.,inconsistent > consistent for self-perspective trials) for dual-task compared to alone trials

Prior to analysis, the assumptions for a repeated measures ANOVA were examined, which include normality and sphericity. As characteristic of reaction time data, the first assumption was violated due to the presence of significant positive skew. To adjust for the non-normal distributions, transformations were conducted on the data; processing costs were transformed by the natural log and reaction time data were winsorized (see Appendix G for distribution statistics before and after transformations). The second assumption for a repeated measures ANOVA is sphericity (Huynh & Feldt, 1970). Sphericity is similar to the assumption of homogeneity of variances that is necessary for a between-subject ANOVA; however, sphericity requires that the differences in variance between each level of the independent variables are equal (i.e., the covariances between each level are equal, Field, 1988). In the case of the current study, sphericity was satisfied since there were only two levels for each independent variable. That is, the assumption of sphericity was met since level-1 visual perspective taking task included only one covariance for each repeated measure.

Finally, a 2 x 2 x 2 x 2 mixed-design ANOVA was conducted with the same three factors (i.e., consistency, perspective and task) as the repeated measures and a between-subject factor of gender (male versus female). Assumptions for a mixed-design ANOVA include independence of observations, normal distributions, and homogeneity of variance. The first assumption, independence of observations, is required for the between-subject factor, which in this case is gender. The assumption of independence of observations involves how the sample is obtained (Howell, 2007). There should be no dependency between participants, which requires that the participants are randomly selected from the population. Nonrandom sampling methods were employed in the current study, thus the

first assumption was violated; however, participants were recruited from two states in several different counties with the goal of obtaining a sample that would increase the likelihood of independence of observations between participants.

To appropriately interpret an F test statistic, in addition to the assumption of normality, a mixed-design ANOVA requires the assumption of homogeneity of variance. Levene's test of equal error variances was examined for each of the eight variables. One variable had a significant p-value (Self Inconsistent trials on the Alone task), indicating homogeneity of variance was violated for that variable ($F_{(1, 36)} = 8.023$, $p = .007$); however, when sample sizes are balanced, ANOVA is relatively robust against violations of equal variance (Tabachnick & Fidell, 2001). All other variables were non-significant indicating these variables had equal error variances (see Appendix I for the Levene statistics). Lastly, Box's (1954) test of equal covariance was non-significant ($F_{(1,36)} = 1.212$, $p = 1.80$), also indicating that the assumption of equal covariance was satisfied.

Theory of mind and Working Memory

The second research question was, "In an older adult sample, how does verbal and spatial working memory contribute to theory of mind?" To test my hypothesis that verbal working memory makes a stronger contribution compared to spatial working memory on theory of mind performance, verbal working memory was added in the first step. After verbal working memory was added to the regression, spatial working memory was added in the second step. The hierarchical regression was conducted using listwise deletion. In addition to examining the R^2 for each predictor variable (i.e., spatial and verbal working memory), the R^2 change and the p-value associated with the F-change was examined. The R^2 change and the F-change examines the amount of additional variance explained

by the second predictor added to the model, which in this case was spatial working memory. Using G*Power 3.1 software, a sample size of 42 was determined as necessary for a regression with two predictor variables, alpha set at .05, power set at .95, and a partial *R* squared set to .25 (Faul, Erdfelder, Buchner, & Lang, 2009).

Prior to conducting the aforementioned regression analysis, the assumptions of linearity, homoscedasticity (i.e., equal variance of the residuals), and normality (i.e., the error distributions should be normally distributed) were assessed. Scatterplots were produced to examine linearity between the outcome variable (theory of mind stories) and the predictor variables (verbal working memory, and spatial working memory). The two scatterplots indicated adequate linearity. To assess normality of residuals (residuals should be normally distributed around zero), probability-probability plots (P-P plots) were examined for each of the variables (theory of mind stories, verbal and spatial working memory). The P-P plots demonstrated that the residuals were approximately normally distributed and therefore was adequately met.

Finally, multicollinearity (i.e., where correlations among two or more variables have almost perfect linear relationships, Mason & Perreault, 1991) in the predictor variables was examined through checking the variance inflation factors (VIF's); VIF's above ten (Mertler & Vannatta, 2005) or in some cases five (O'Brien, 2007) are highly correlated. For the current study, the VIF's were 1.122, indicating this assumption was adequately met.

**Level-1 Visual Perspective Taking
and Working Memory**

My third research question was, "In an older adult sample, how does verbal and spatial working memory contribute to level-1 visual perspective taking?" Two

hierarchical regression analyses were conducted to answer this research question. The first examined the impact of verbal and spatial working memory on the level-1 visual perspective taking task alone. The second examined the impact of verbal and spatial working memory on the dual-task version. Thus, the two hierarchical regression analyses used different outcome variables with the same predictor variables. To test my hypothesis that spatial working memory makes a stronger contribution compared to verbal working memory on level-1 visual perspective taking performance, spatial working memory was added in the first step. Next, verbal working memory was added to the model in the second step (i.e., after verbal working memory). Listwise deletion was used while carrying out the regression. In addition to examining the R^2 for each predictor variable (i.e., spatial and verbal working memory), R^2-change and the corresponding p-value associated with the F-change was examined for verbal working memory, which was added in the second step.

The same assumptions of normality, linearity, and homoscedasticity (i.e., equal variance of the residuals) that were examined for the previous hierarchical regression were also examined prior to this second regression analysis. Since the predictor variables are the same for both regressions, only the assumptions specific to level-1 visual perspective taking task needed to be examined.

Four scatter plots examined the assumption of linearity; first, with level-1 visual perspective taking alone on the y-axis and verbal working memory (i.e., digit span sequence) on the x-axis; and second, with level-1 visual perspective taking alone on the y-axis and spatial working memory on the x-axis. The last two scatter plots examined the dual-task version of level-1 visual perspective taking on the y-axis and each of the

working memory measures on the x-axis. The scatterplots demonstrated that the assumption of linearity was met. Residual values for level-1 visual perspective taking were examined with P-P plots. All level-1 visual perspective taking variables showed adequate normality of the residuals (i.e., residuals were approximately equally distributed around zero).

Demographics

Data collected from the self-report demographics survey have been used to describe the sample. Descriptive statistics were calculated for the two continuous variables of age and education. Frequency distributions were examined for all categorical demographic variables including, marital status, retirement (i.e., yes or no), exercise, health, familiarity with computers, part-time or full-time work, and finally volunteering and homemaker status (i.e., yes or no). See appendix D for demographic characteristics of the sample.

CHAPTER IV

RESULTS

The results are organized into three broad sections based on their corresponding

research questions. First, the results for the repeated measures ANOVA are presented,

which corresponds to the first research question. The second and third sections report the

results for the hierarchical regression, which corresponds to the second and third research

questions. The statistical assumptions were presented in the previous chapter in the data

analyses sections. All assumptions for a repeated measures ANOVA were adequately

met. To address the positive skew that is characteristic of reaction time data,

transformations on the level-1 visual perspective taking variables were conducted. Prior

to reporting the results for the first research question, the variables are reviewed and brief

summaries of the hypotheses are provided.

**Is there Evidence of Cognitively Efficient Processes in
Level-1 Visual Perspective Taking in an
Older Adult Sample?**

To review, the level-1 visual perspective taking task includes three independent

variables: perspective (self vs. other), consistency (consistent vs. inconsistent), and task

(alone vs. dual). The results reported in the current section pertains to the first four

hypotheses testing for egocentric and altercentric interference effects as well as the role

of executive functioning during level-1 visual perspective taking. The first hypothesis

tested if older adults are prone to egocentric interference. Egocentric interference

corresponds to slower reaction times for inconsistent compared to consistent trials when

being asked to judge the agent's perspective (i.e., Other condition). The second

hypothesis tested if older adults demonstrate altercentric interference. Altercentric

interference corresponds to slower reaction times for inconsistent compared to consistent

trials when being asked to judge owns own perspective (i.e., Self condition). To be clear,

if processing costs are larger for inconsistent compared to consistent trials when

participants make judgments for the other perspective, then this corresponds to egocentric

interference. If processing costs are larger for inconsistent compared to consistent trials

when participants respond to their own perspective (i.e., self perspective), then this

corresponds to altercentric inference effects.

The effect of the dual task on level-1 visual perspective taking tests for the third

and forth hypotheses regarding the role of executive functioning in level-1 visual

perspective taking. Two sets of analysis are reported in the following section: a)

processing costs as the dependent variable, and b) reaction time as the dependent variable.

Processing costs were calculated for each participant by dividing reaction time by the

proportion of correct response in each condition; hence, smaller processing costs are an

indication of better performance (i.e., quick response time and high accuracy).

Processing Costs

Descriptive statistics for the initial processing costs (without transformations) are

presented in Table 5 (see Appendix J for descriptive statistics with the natural log

transformation). A 2 x 2 x 2 repeated measures ANOVA conducted with the natural log

transformation as the dependent variable revealed two main effects and two significant

interactions. There was a main effect of consistency (Inconsistent > Consistent; $F_{(1, 39)}$ =

64.243, $p < .000$, $\eta_p^2 = .622$). The consistency effect tested for the difference in

conditions when the participant's and the agent's perspectives match (i.e., Consistent)

compared to when the perspectives do not match (i.e., Inconsistent). There was a main

effect for task condition (Dual > Alone; $F_{(1, 39)} = 4.713$, p = .036, $\eta_p^2 = .108$). The

analysis did not reveal a main effect for perspective ($F_{(1, 39)} = 3.079$, p = .087, $\eta_p^2 = .073$).

Significant interactions were found between task and perspective ($F_{(1, 39)} = 6.855$, p

$= .013$, $\eta_p^2 = .149$) and between perspective and consistency ($F_{(1, 39)} = 8.479$, $p = .006$, η_p^2

$= .179$). No significant interaction was found between task and consistency ($F_{(1, 39)}$

$= .447$, $p = .508$, $\eta_p^2 = .011$). See Figure 3 for processing costs by each condition.

Table 5

Descriptive Statistics for L-1 VP: Processing Costs without Transformations

	N	Mean	SD	Minimum	Maximum
Alone					
Other Consistent	40	969.45	226.00	661.00	1553.00
Other Inconsistent	40	1358.30	650.35	616.00	4183.18
Self Consistent	40	975.82	283.47	608.00	1882.00
Self Inconsistent	40	1118.52	491.35	647.00	2820.36
Dual					
Other Consistent	40	1063.54	509.57	548.00	3333.33
Other Inconsistent	40	1364.98	582.32	483.00	3137.93
Self Consistent	40	1164.13	485.04	639.00	3196.15
Self Inconsistent	40	1257.77	502.73	664.00	4519.52

Note. L-1VP = level-1 visual perspective taking
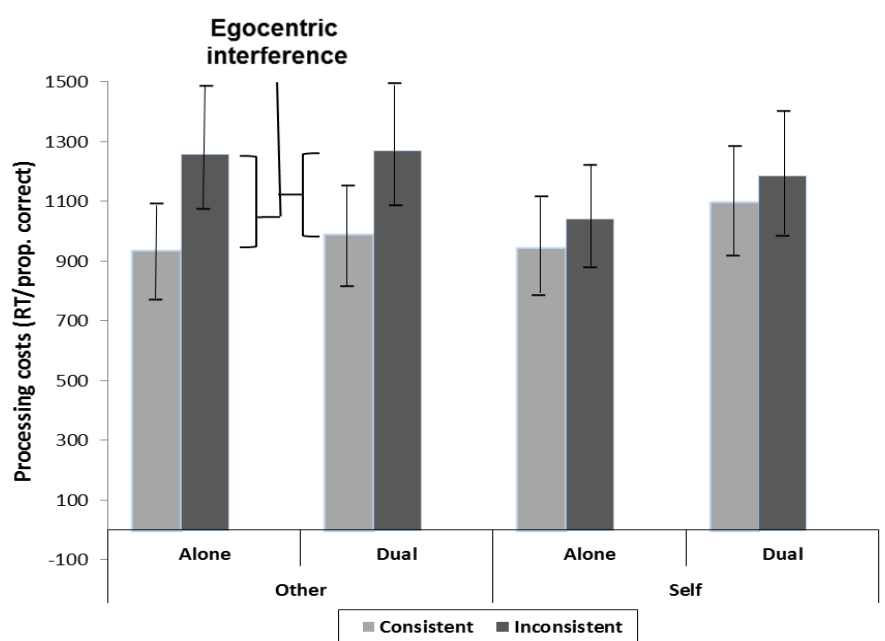
Figure. 3. Processing Costs for each Condition

Notes: The error bars are confidence intervals (CI) calculated with the Loftus and Masson (1994) formula in the natural log form (CI, ±.00126) then transformed back to reaction time units by calculating the antilog after the analysis. The curved brackets show the egocentric interference, which is indicated by the faster Consistent compared to Inconsistent conditions for the Other perspective.

Post hoc analysis examined the interaction between task and perspective, which revealed one significant contrast. The Self perspective was significantly faster for the Alone (self alone = 989.30 ms) compared to the Dual task (self dual = 1137.97 ms) condition. That is, a task effect was found only when participants judged their own perspective. See figure 4 for an illustration of the interaction. Table 6 reports the pairwise contrasts, which includes confidence intervals derived by the Loftus and Masson (1994) method for repeated measures ANOVA's (95% CI = ± .058971).
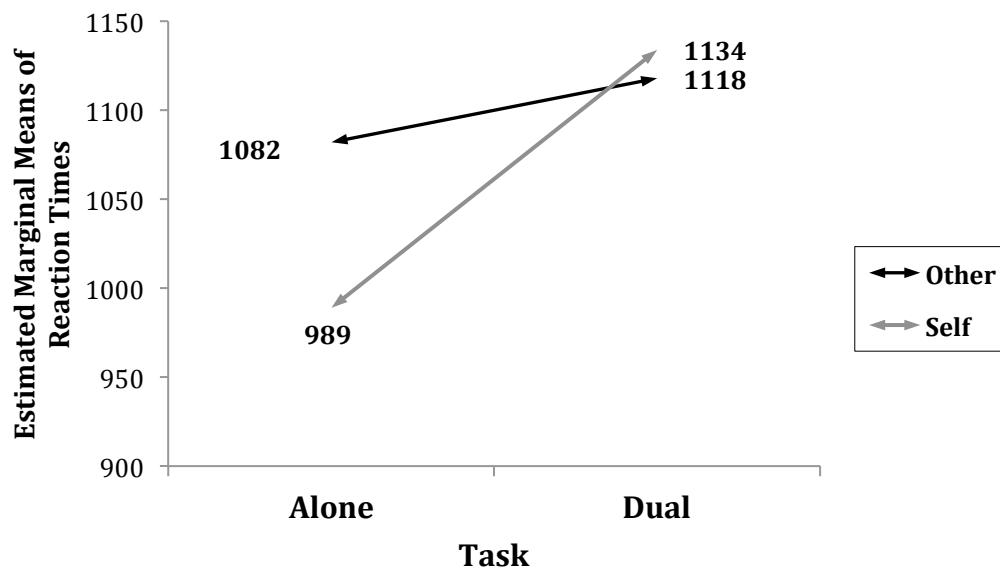
Figure. 4. Line Graph of Task by Perspective Interaction for Processing Costs
Notes: A significant contrast was found between Alone and Dual task conditions for Self perspective.

Table 6

Task by Perspective Interaction with Processing Costs as the Dependent Variable

		95% Confidence Intervals (CI)	
Condition	Mean	Lower Bound	Upper Bound
Alone			
Other	1082.69	1020.48	1148.22
Self	989.30	932.65	1049.40
Dual			
Other	1117.69	1053.66	1185.56
Self	1137.97	1072.80	1207.09

Note. CI's derived from the Loftus and Masson (1994) formula in the natural log (CI ±. .058971) then transformed using the antilog. The significant contrast was between the Alone and Dual task conditions for the Self perspective (note the non-overlapping CI's).

Post hoc analysis examined the interaction between consistency and perspective. One significant contrast was found. A significant consistency effect (inconsistent > consistent) was found for Other but not for Self perspective. That is, for the Other perspective (i.e., when participants were asked to judge the avatar's perspective) participants were significantly slower for the Inconsistent conditions (i.e., when the perspectives did not match, inconsistent = 1262.69 ms) compared to the Consistent conditions (i.e., when the perspectives matched, consistent = 958.15 ms). Whereas, there was no difference between consistency conditions for the Self perspective (i.e., when participants were asked to judge their own perspective). See Figure 5 for the line plot and Table 7 for the means and confidence intervals for this pairwise contrast.
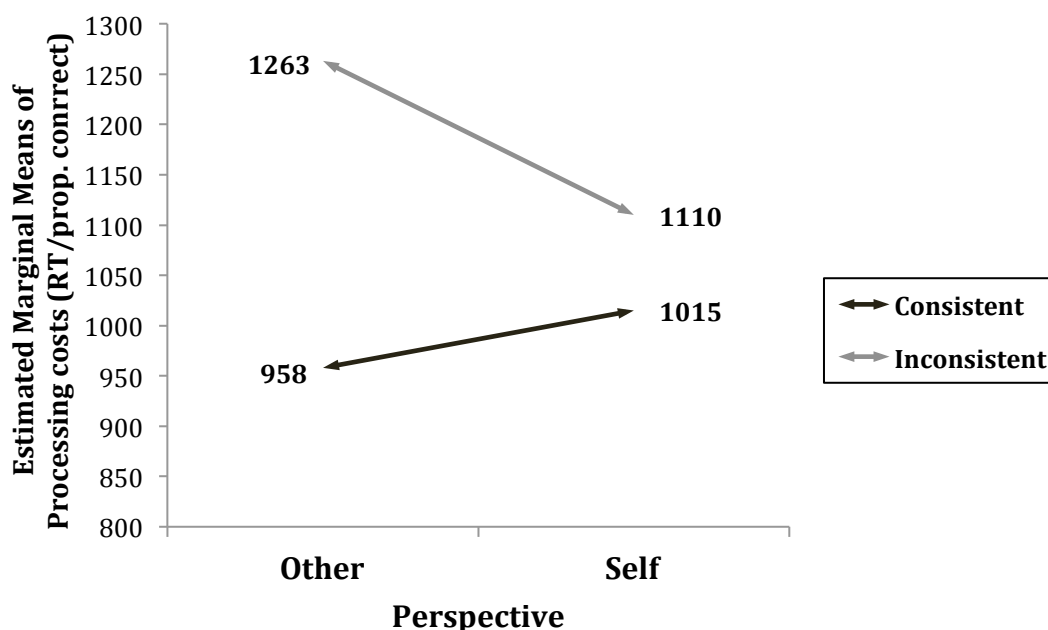
Figure. 5. Line Graph of the Perspective by Consistency Interaction for Processing Costs
Notes: The significant contrast was between the Consistent and Inconsistent conditions for the Other perspective.

Table 7

Perspective by Consistency Interaction with Processing Costs as the Dependent Variable

		95% Confidence Intervals (CI)	
Condition	Mean	Lower Bound	Upper Bound
Other			
Consistent	958.15	874.30	1050.04
Inconsistent	1262.69	1152.19	1383.79
Self			
Consistent	1015.36	926.50	1112.74
Inconsistent	1109.87	1012.74	1216.31

Note. The Loftus and Masson (1994) formula was used to calculate the CI (± .091581), followed by an antilog calculation. The only contrast with non-overlapping confidence intervals (i.e. indicating a significant effect) was between other Consistent and other Inconsistent conditions for the Other perspective.

Reaction Time

Descriptive statistics for reaction time after the variables were winsorized are displayed in Table 8 (see Appendix K for descriptive statistics for reaction time before the variables were winsorized). The ANOVA with reaction time as the dependent variable revealed the same main effects and interactions as the processing costs analysis. A main effect of consistency was found ($F_{(1, 39)} = 53.251$, $p < .000$, $\eta_p^2 = .577$) with consistent conditions (m = 956.67 ms) significantly faster than inconsistent conditions (m = 1058.63 ms). A main effect of task ($F_{(1, 39)} = 4.350$, $p = .044$, $\eta_p^2 = .100$) revealed that the alone conditions (m = 974.78 ms) were significantly faster than dual task conditions (m = 1040.53 ms). No significant perspective effect was found ($F_{(1,41)} = .043$, $p < .837$,

$\eta_p^2 = .001$). Two significant interactions were found; task by perspective ($F_{(1, 39)} = 7.114$, $p = .011$, $\eta_p^2 = .154$) and perspective by consistency ($F_{(1, 39)} = 15.908$, $p < .000$, $\eta_p^2 = .290$). Thus, before interpreting the main effects, the interactions were examined further. No significant interaction was found between task and consistency ($F_{(1, 39)} = 2.662$, $p = .111$, $\eta_p^2 = .064$). See Figure 6 for results by each level.

Table 8

Descriptive Statistics for L-1 VP task: Reaction Times after data were Winsorized

	N	Mean	SD	Minimum	Maximum
Alone					
Other Consistent	40	891.95	192.85	587.00	1303.90
Other Inconsistent	40	1105.05	286.26	497.00	1786.40
Self Consistent	40	927.58	230.36	490.00	1368.10
Self Inconsistent	40	974.52	308.58	471.00	1682.40
Dual					
Other Consistent	40	953.29	296.57	548.00	1710.30
Other Inconsistent	40	1087.73	290.77	483.00	1825.00
Self Consistent	40	1053.88	309.58	639.00	1815.50
Self Inconsistent	40	1067.24	251.54	664.00	1600.70
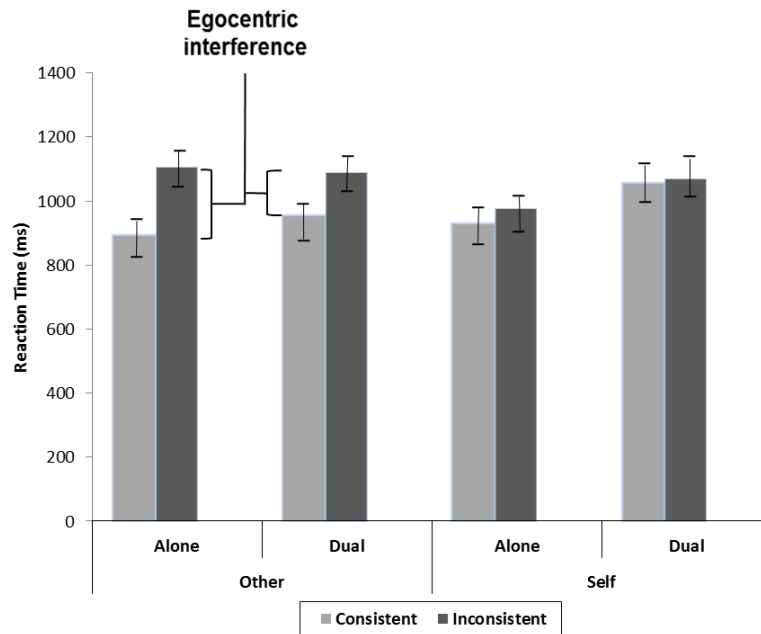
Figure. 6. Reaction time for each condition. The error bars are confidence intervals calculated with the Loftus and Masson (1994) formula (CI, ± 42.723). The curved brackets show the egocentric interference, which is indicated by the faster reaction times for the Consistent compared to the Inconsistent conditions for the Other perspective.

The interaction between task and perspective was examined further with a post hoc pairwise contrast. The Self perspective was significantly faster for the Alone (m = 951.05 ms) compared to the Dual task condition (m = 1060.56 ms). No other pairwise contrasts were significant. See Figure 7 for an illustration of the interaction. Table 9 provides descriptive statistics and confidence intervals for this contrast.
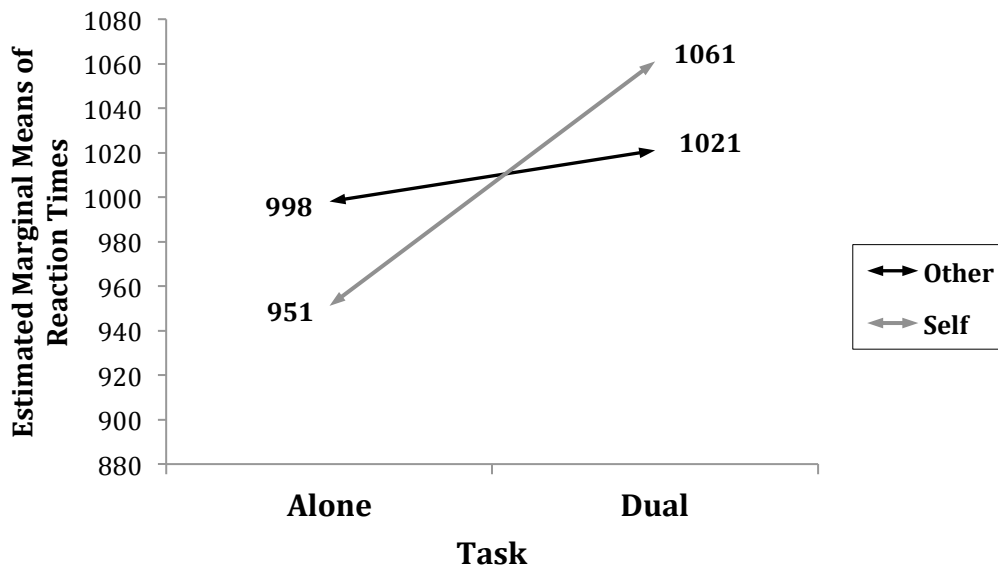
Figure. 7. Line graph of task by perspective interaction for reaction time. A significant contrast was found between Alone and Dual task conditions for Self perspective.

Table 9

Task by Perspective Interaction with Reaction Time as the Dependent Variable

			95% Confidence Intervals (CI)	
Condition	Mean	Std. Error	Lower Bound	Upper Bound
Alone				
Other	998.50	36.22	951.58	1045.41
Self	951.05	41.14	904.13	997.97
Dual				
Other	1020.51	42.89	973.59	1067.42
Self	1060.56	40.07	1013.64	1107.47

Note. Loftus and Masson (1994) formula used to calculate the CI's (± 42.723). The only significant contrast is between the alone and dual task condition for self perspective.

The pairwise post hoc comparison between consistency and perspective revealed a significant consistency effect for Other perspective (consistent = 922.62 ms; inconsistent = 1096.34 ms) but not for Self perspective (Figure 8). That is, when participants responded to conditions being asked to judge the Other perspective (i.e., the agent's perspective), they were significantly faster on Consistent conditions (i.e., when the participant's and agent's perspectives matched, m= 958.15 ms) compared to Inconsistent conditions (i.e., when the participant's and agent's perspective did not match, m= 1262.69 ms). There was no consistent effect for the self perspective conditions. Table 10 provides the descriptive statistics and confidence intervals for these pairwise contrasts.

Table 10

Perspective by Consistency Interaction with Reaction Time as the Dependent Variable

			95% Confidence Intervals (CI)	
Condition	Mean	Std. Error	Lower Bound	Upper Bound
Other				
Consistent	922.62	31.98	857.93	987.30
Inconsistent	1096.39	39.77	1015.94	1176.83
Self				
Consistent	990.73	40.04	909.74	1071.71
Inconsistent	1020.88	38.72	942.57	1099.19

Note. Loftus and Masson (1994) CI ± 51.499. The only significant pairwise contrast for between consistent and inconsistent for the other perspective.
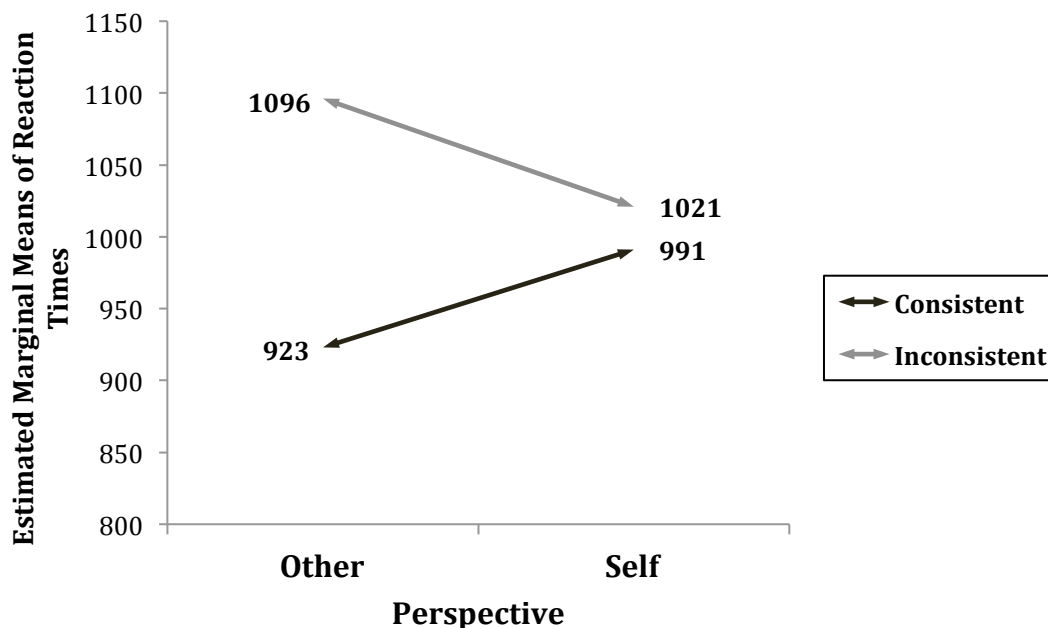
Figure. 8. Line Graph of the Perspective by Consistency Interaction for Reaction Time
Notes: The significant contrast was between the Consistent and Inconsistent conditions
for the Other perspective.

Predicted versus Measured
Reaction Time

Researchers have developed algebraic functions to estimate older adult reaction

time based on young adult data. To consider how the results of the current sample

compare to predicted reaction times based on such functions, young adult reaction times

from a previous study (Qureshi, 2008) utilizing a similar level-1 visual perspective taking

task was entered into a formula as described by Verhaeghen (2006). In consideration of

the task demands of level-1 visual perspective taking, a formula for spatial stimuli was

employed. See Table 11 for predicted reaction times for older adults based on a young

adult sample as well as the actual reaction times demonstrated by the current older adult

sample.

Table 11

Predicted Older Adult Reaction Time versus Data Collected in the Current Sample

	Young adults	Predicted older adults	Current sample
Alone			
Other consistent	595	920	970
Other inconsistent	780	1290	1360
Self consistent	620	970	975
Self inconsistent	770	1270	1120
Dual			
Other consistent	775	1280	1060
Other inconsistent	1450	2630	1360
Self consistent	775	1280	1160
Self inconsistent	1200	2130	1260

Note. The young adult reaction times were from Qureshi (2008). The predicted reaction times were based on Verhaeghen's (2006) formula for spatial tasks: older adult reaction times = 2*young adult reaction times-270.

Gender Analysis

Using reaction time as the dependent variable, the 2 x 2 x 2 x 2 mixed-design ANOVA with consistency (consistent versus inconsistent), perspective (self versus other), and task (alone versus dual) as the within subject factors and gender (male versus female) as the between-subject factor revealed an overall gender effect ($F_{(1, 38)}$ = 5.495, p = .024, d = .73). Males were significantly faster (m = 926.24 ms, SE = 47.931) than females (m

= 1081.31 ms, SE = 45.591). No significant gender interactions were found. The mixed-design ANOVA using processing cost as the dependent variable did not reveal any significant gender effects. That is, in contrast to the reaction time analysis, processing cost did not reveal an overall gender effect ($F_{(1, 38)}$ = 1.962, p = .169).

In an Older Adult Sample, how does Spatial and Verbal Working Memory Contribute to Theory of Mind?

Prior to reporting the results of the hierarchical regression analyses, a description of the theory of mind story task and the measures of working memory follows. The theory of mind story task had a mean of 15.48 (out of a 20 points possible) with a standard deviation of 2.54. There were three outliers with low scores that were disconnected from the rest of the distribution. All analyses were conducted with the full sample; however, I examined the mean and standard deviation of the theory of mind story task with these three outliers dropped to examine central tendency and spread for the majority of the sample. The mean and standard deviation with the three outliers dropped were 16.03 and 1.75 respectively, indicating that the variance for the majority of the distribution was small. The current sample means and standard deviation for the digit span forward, backward, and sequence were 10.21 (2.28), 8.48 (1.85), and 8.86 (1.83) respectively. The mean of the total digit span was 27.55 with a standard deviation of 4.91. The mean symbol span score for current study was 21.52 with a standard deviation of 5.51. See Table 12 for a summary of descriptive statistics for the theory of mind story task and the working memory measures.

A hierarchical regression analysis examined if spatial working memory explained variance in the theory of mind story task above and beyond verbal working memory. Verbal working memory was added in the first step, which produced a significant model

$(F_{(1, 40)} = 5.867, p = .02, R^2 = .128)$. At the second step spatial working memory was added, which produced an overall statistically significantly model, $F_{(2, 39)} = 3.539, p = .039$. The R^2 change after adding spatial working memory was .026, which was not statistically significant (F change = 1.184, $p = .283$), providing an overall R^2 of .154.

Table 12

Descriptive Statistics for Theory of Mind Task and Working Memory Measures

	N	Mean	SD	Minimum	Maximum
SST					
Theory of mind	42	15.48	2.54	8	20
Control stories	42	16.3	2.56	11	20
Digit span total	42	27.55	4.91	18	40
Digit span forward	42	10.21	2.28	6	16
Digit span backward	42	8.48	1.85	5	14
Digit span sequence	42	8.86	1.83	5	12
Symbol span	42	21.52	5.51	9	33

Note. SST = Strange stories Task, which includes theory of mind stories and control stories; SD = standard deviation; Digit span is a measure of verbal working memory from the Wechsler Adult Intelligence Scale-IV and symbol span is a measure of visual working memory from the Wechsler Memory Scale-IV.

**In an Older Adult Sample, how does Spatial and Verbal
Working Memory Contribute to Level-1
Visual Perspective Taking?**

Two hierarchical regression analyses examined if verbal working memory

explained variance in the level-1 visual perspective taking task above and beyond spatial

working memory. For the first regression, processing costs for the alone task was entered

as the outcome variable. The first step in the analysis revealed that spatial working

memory (as measured by Digit Span total) did not contribute significantly to the model,

$F_{(1, 39)} = 3.47$, $p = .07$. At the second step verbal working memory was added, which did

not contribute to the model significantly ($F_{(2, 38)} = 1.843$, $p = .172$). The R^2 change after

adding verbal working memory was not significant (R^2 change .088, F change = .284, p

$= .597$) giving an overall R^2 of .088.

For the second regression, processing costs for the dual task was entered as the

outcome variable. Spatial working memory was again entered in the first step, $F_{(1, 39)} =$

2.064, $p = .159$). Verbal working memory was added in the second step, which did not

contribute to the model significantly ($F_{(2, 39)} = 1.631$, $p = .209$). The R^2 change after

adding verbal working memory was not significant (R^2 change = .029, F change = 1.188,

$p = .283$) providing an overall R^2 of .079.

CHAPTER V

DISCUSSION

The current study investigated mental state understanding during aging with two primary goals. First, I set out to examine if there is evidence of automatic and cognitively efficient processes involved in mental state understanding in an older adult sample. My second goal was to investigate how verbal and spatial working memory mediates performance in mental state understanding in older adults. An aging in place sample was obtained with the goal of increasing the generalizability of the findings to the larger population of older adults (Black, 2008). The first section of the current chapter begins with a discussion of the results in context with my first research question. The second section of the current chapter presents the results associated with my second and third research questions followed by a discussion of the conclusions and implications of results in context of the broader literature. Finally, I finish with suggestions for future research and discuss the limitations of the current study. Prior to discussing the results, the following is a summary of my three research questions and the associated hypotheses.

Q1   Is there evidence of cognitively efficient processes in a level-1 visual perspective taking task in an older adult sample?

H1   Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when being asked to judge *other perspective* on the level-1 perspective taking task (i.e., indicating egocentric bias).

H2   Older adults will perform significantly slower and/or more error prone when their perspective differs from that of the avatars perspective when

being asked to judge *self perspective* on the level-1 perspective taking task (i.e., indicating altercentric bias).

H3   In regards to examining whether executive function is involved in selection processes, the dual-task trials will result in larger processing costs in consistent and inconsistent trials with disproportionately larger costs in the inconsistent trials for older adults.

H4   In regards to examining whether executive function is involved in calculation processes, dual-task trials will result in a significantly larger altercentric effect for older adults compared to alone trials. If this result is confirmed, then this would suggest that calculation of the other perspective does not rely on executive function processes.

Q2   In an older adult sample, how does verbal and spatial working memory contribute to theory of mind?

H5   Verbal working memory will make a stronger contribution to performance on a theory of mind story task compared to spatial working memory.

Q3   In an older adult sample, how does verbal and spatial working memory contribute to level-1 visual perspective taking?

H6   Spatial working memory will make a stronger contribution to performance on a level-1 visual perspective taking task compared to verbal working memory.

Level-1 Visual Perspective Taking

The first research question was, "Is there evidence of cognitively efficient processes in a level-1 visual perspective taking task in an older adult sample?" Answering this question will be accomplished by considering the entire set of results for the level-1 visual perspective taking task. Thus, the results testing each of my first four hypotheses are considered individually. The current study used a level-1 visual perspective taking task where participants made either self or other judgments regarding the number of red dots that were visible on the computer screen. In some conditions, the perspective of the participant and the perspective of the agent (i.e., a computer generated avatar) did not match; these were inconsistent trials. In other conditions, the perspective

of the participant and the agent did match; these were consistent trials. Thus, a consistency effect tested the difference between inconsistent and consistent perspectives (i.e., mismatched versus matched respectively). A perspective effect was tested by comparing the self and other perspectives. Finally, participants completed the level-1 visual perspective taking task alone and as a dual task with a secondary inhibition task. The difference between the alone and dual task conditions tested for a task effect. The purpose of including the dual task was to examine the impact of inhibition demands on level-1 visual perspective taking. The critical prediction for the dual task was a hypothesized interaction between task and consistency such that the dual task would result in a significantly larger consistency effect compared to the alone task. This interaction would suggest that inhibitory aspects of executive functioning is not involved when older adults calculate the agent's perspective; thus, providing evidence of cognitively efficient processes in mental state understanding during aging.

The ANOVA revealed a main effect of consistency, however, a significant interaction between consistency and perspective was found; thus, follow-up analysis was necessary before the consistency effect could be interpreted. A pairwise contrast indicated that the consistency effect was significant when participants judged the agent's perspective (i.e., other condition) but no consistency effect was found when participants judged their own perspective (i.e., self conditions). Thus, the first hypothesis examining if older adults are prone to egocentric bias was supported. That is, when participants were asked to judge the perspective of the agent, they were significantly slower when their own perspective did not match (i.e., inconsistent) compared to when their perspective did match the agent's perspective (i.e., consistent). Analysis using

processing costs (i.e., reaction time divided by the proportion of correct responses), as well as reaction time alone, resulted in the same outcome. To reiterate, these results indicate that older adults are prone to egocentric interference as indicated by the significantly larger processing costs and slower reaction time for inconsistent compared to consistent trials for other perspective.

The second hypothesis examined if there was evidence of altercentric interference effects in an older adult sample. As stated above, the follow-up analysis examining the interaction between consistency and perspective indicated that there was no consistency effect for self trials. This is to say, when participants judged their own perspective there were no statistically significant interference effects (i.e., difference between inconsistent and consistent conditions) when the agents' perspective differed from their own.

In regards to examining if inhibitory control is involved in selection processes (i.e., when participants make a response selection), I predicted that dual-task trials would result in larger processing costs (i.e., slower reaction times and higher error rates) for both consistent and inconsistent conditions with disproportionately larger costs in the inconsistent trials. This hypothesis would have been supported by a significant task by consistency interaction; however, this hypothesis was not supported in the current study. I hypothesized that dual-task trials would result in larger altercentric interference effects compared to the alone trials; however, no altercentric effects were found in either alone or dual-task conditions. Thus, the forth hypothesis was not supported.

Finally, a significant interaction between task and perspective was found. No *a priori* hypothesis for made for this interaction. Follow-up analysis indicated that the self perspective was significantly slower for the dual task compared to the alone task;

whereas, no significant difference was found for the other perspective. In other words, when participants judged their own perspective they were significantly slower and more error prone in the dual-task trials compared to the alone trials. There were no theoretical reasons to predict a significant task by perspective interaction.

Egocentric Interference

The significant consistency effect when participants judged the agent's perspective (i.e., Other perspective) provides evidence that older adults are prone to egocentric interference. Egocentric bias, that is, bias due to self-knowledge interfering with the accurate assessment of another individual or perspective, have been observed from the earliest stages of development (Bjorklund & Green, 1992; Carlson & Moses, 2001; Piaget & Inhelder, 1956). For example, 14 month olds responded egocentrically when infants watched an experimenter either express enjoyment or disgust after taking a food; instead of predicting which food the experimenter would prefer (based on the enjoyment or disgust reactions of the experimenter), the 14 old month infants responded egocentrically (that is, based on their own preferences, Repacholi & Gopnik, 1997).

In the preschool years, errors that children make in false belief tasks tend to be systematic egocentric errors (e.g., Doherty & Wimmer, 2005). In a false belief task (Wimmer & Perner, 1983), children see a character, Sally, place an object in a round box and then leave the room. A different character, Ann, transfers the object from its original box into a different square box. When Sally returns, participants are asked where Sally will look for the object. Thus, in the Sally-and-Anne-task, participants must inhibit their knowledge of where the object is located (which has been moved from a previous location) to correctly identify where Sally thinks the object is located (which is a false-

belief). Preschool children give responses to this task and variations of this task from the knowledge of their own perspective instead of the point of view of the agent, which is what is being asked of them (Cassidy, 1998; Saltmarsh, Mitchell, & Robinson, 1995)

When children's inhibitory control improves they are more likely to inhibit their own perspective and explicitly acknowledge that the other agent has a false belief (Leslie et al., 2004). The ability to set aside one's own knowledge is considered one of the cognitive requirements to passing false belief tasks (Birch & Bloom, 2007; Carlson & Moses, 2001; Leslie & Polizzi, 1998). In fact, children's performance on perspective-taking tasks has been shown to correlate with false belief tasks (Doherty & Wimmer, 2005; Hamilton, Brindley, & Frith, 2009; Perner & Leekam, 2008; Wimmer & Doherty, 2011). Perner and Roessler (2012) discussed that to pass a false belief task children must be able to switch between their own perspective and that of an agent's. There is also evidence beyond false belief tasks that children in general formulate ideas about others using their own egocentric perspective (Harris, Johnson, Hutton, & Andrews, 1989; Mossler, Marvin, & Greenberg, 1976; Taylor, Esbensen, & Bennett, 1994).

Even though children are capable of switching between self and other perspectives after the age of 4, adults continue to make egocentric errors (Epley et al., 2004; Keysar, Barr, & Horton, 1998) in addition to errors in perspective taking tasks (Keysar, 1994). For instance, after a series of experiments, Epley, Keysar, Van Boven, and Gilovich (2004) concluded that adults make judgments regarding other peoples' perspectives by making serial adjustments from their own egocentric bias. That is, when considering someone else's perspective, participants start with their egocentric bias as an anchor and make adjustments from this point of view.

There is evidence that suggests that even though adults are prone to egocentric perspectives they are better than children at correcting away from their initial egocentric perspective (Epley et al., 2004). Nevertheless, several bodies of literature suggest that a pervasive cognitive bias toward egocentrism persists into adulthood and influences a wide range of social judgments (Gilovich & Savitsky, 1999; Nickerson, 1999; Royzman, Cassidy, & Baron, 2003). The current study provides evidence that older adults continue to be prone to egocentric interference.

At least one study examined visual perspective taking across the adult lifespan. Inagaki et al. (2002) examined young adult (m = 22.2 years old), middle-aged (m = 45.8 years old), and older adult (m = 74.6 years old) performance on two variations of Piaget's Three Mountain Task (Piaget & Inhelder, 1956). Participants viewed two cubes sitting on a two by two grid. In one variation of the task, participants were required to mentally rotate the grid and indicate where the cubes would be located after the grid was rotated. In the other variation, participants were required to imagine what their perspective would be if they moved to a different location. The former task measured the participant's ability to mentally rotate an image (i.e., object-mental rotation) whereas the latter task measured participant's ability to represent a different perspective (i.e., subject-mental rotation). Results indicated that older adults made more egocentric errors than young adults and middle-aged adults on the subject-mental rotation but not the object-mental rotation task. Inagaki et al. (2002) interpreted these results to suggest that older adults had more difficulty with imagining another individual's perspective but demonstrated preserved object rotation ability. In the current study no age comparisons can be made; however, it is interesting to consider the evidence from Inagaki et al.'s

(2002) study that older adults demonstrated an increase in egocentric errors compared to young and middle-aged adults when they were asked to take a different perspective but not when they were asked to mentally rotate an object.

Altercentric Interference

The results from the current study did not find evidence of altercentric interference effects in older adults. Thus, there is no evidence present that older adults automatically judged the agent's perspective. These results sit in direct contrast to three studies using young adult participants and one study with 6, 8 and 10 year old children as participants. To be clear, Samson, Apperly, Braithwaite, Andrews, and Scott (2010) were the first to examine level-1 perspective taking in adults and found that participants were significantly slower when judging self perspective when the agent's perspective did not match their own. In a study investigating level-1 perspective taking in adults and children aged 6 to 10 years old, results indicated adults were overall faster but were not better at reducing irrelevant perspective intrusions compared to the children (Surtees & Apperly, 2012); thus, there were no age-related differences in regards to egocentric and altercentric effects. In contrast, the results from the current study found no evidence that older adults automatically process the perspective of the agent when they are being asked to judge their own perspective.

While it is important to be cautious about what can be extrapolated from the absence of evidence, it is worthwhile to consider possible explanations regarding the lack of altercentric interference effects in older adults. For one, it is possible that the automatic and cognitively efficient system declines with age. The second possibility is that there are limits to the automatic system and the cognitive capacity of older adults

exceeds these limits. Lastly, it is possible that the model as conceptualized by Apperly and colleagues overestimated the degree to which the automatic processes are free of executive control. These possibilities are considered in turn.

First, one possible explanation is that automatic cognitive processes associated with mental state understanding decline with age. That is, the results of the current study are in direct opposition to the findings of three previous studies (with young adult samples and six to ten year old children) that suggest that level-1 visual perspective taking involve cognitively efficient and automatic processes. Thus, it is possible that the cognitively efficient system present in children and young adults deteriorates during the aging process. This offers an explanation for the research that suggests mental state understanding declines with age above and beyond domain-general cognitive processes. For example, in a review of theory of mind during aging, Moran (2013) concluded that there is evidence of age-related decline associated with mental state understanding that is at least partially independent of general cognitive decline.

Several authors have suggested that moving away from egocentric bias requires cognitive effort. When considering the evidence in the current study that older adults are prone to egocentric interference but not to interference from other's perspectives, it may be the case that during aging, taking another individual's perspective requires more cognitive effort compared to young adults. For example, studies have found age-related decline in mental state stories but not in control stories (i.e., the control stories were not negatively correlated with age but the mental state stories were). This differential performance between theory of mind and control stories suggest that age-related impairments are specifically due to difficulties with making mental state attributions and

not simply due to general cognitive decline (Charlton et al., 2009; Sullivan & Ruffman, 2004). Thus, it is possible that an age-related impairment in cognitively efficient mechanisms for mental state understanding may be contributing to the age-related deficits in theory of mind tasks. That is, the evidence that suggests older adults demonstrate mental state understanding decline that is not fully explained by general cognitive decline (i.e., domain-general decline) might be partially due to a loss of cognitively efficient processing for representing other's mental states during the aging process.

The suggestion that automatic processes in mental state understanding may decline with age diverges from the literature that suggests that implicit processes are less likely to decline compared to resources associated with high cognitive control (e.g., Zelazo & Craik, 2004). For instance, there is evidence that implicit memory is stable during the aging process (Ballesteros & Reales, 2004). Fleischman, Wilson, Gabrieli, Bienias, and Bennett (2004) conducted a longitudinal study and found that explicit memory declined over 4 years and implicit memory remained stable. Other cognitive domains that have been shown to demonstrate resilience to age-related change are implicit learning (Gaillard, Destrebecqz, Michiels, & Cleeremans, 2009) and implicit attitudes and stereotypes (Hummert, Gartska, O'Brien, Greenwald, & Mellott, 2002).

The differential age-related decline between implicit and explicit processes fits with neuropsychological research that suggests that implicit and explicit memory are disassociated (Tulving & Schacter, 1990). Therefore, the results from the current study are particularly striking because of the contrast to evidence that implicit processes are relatively impervious to age-related decline. It should be emphasized that the level-1

visual perspective taking task employed in the current study is not an implicit task. The

task requires an explicit response and the task demands a relatively high degree of effort

and attention on the part of the participants to complete the task. Recall that in order to

make a response, participants must first keep in mind the perspective (i.e., self or other)

and the number shown on the screen, and then subsequently make a selection (i.e., an

explicit decision) regarding the number of dots that can be viewed from the perspective

that was indicated to them. In this task, implicit perspective taking is inferred by

comparing the consistent to inconsistent perspectives. It should be stressed, however,

that when participants are required to give their own perspective (i.e., self conditions)

they are not required to explicitly judge the agent's perspective. Therefore, comparing

the difference in reaction times between consistent and inconsistent trials represents a

good test for implicit perspective taking. Thus, if it is indeed the case that a cognitively

efficient and automatic system for representing other's mental states declines with age,

then this rests in opposition to the evidence that implicit cognitive processes in other

domains are resistant to age-related decline.

Earlier I suggested that there are three points of view regarding the lack of

evidence of altercentric interference in the current older adult sample. First, I argued that

the automatic and efficient cognitive processes associated with mental state

understanding might actually be in decline with age. The second possibility is that the

cognitively efficient mechanism underlying level-1 visual perspective taking is

constrained by limits, which older adults do not meet. The conceptualization of limits of

cognitive efficiency is built around the dual route model of mental state understanding.

In Apperly and Butterfill's (2009) framework, the dual route model is based on the

premise of two discrete systems that work in parallel; one system is characterized by fast and automatic processing, while the other system is slow and cognitively demanding. If there are distinct systems for understanding mental states, then Apperly (2010) contends that there must be limits to the cognitively efficient module. That is, in order for the dual route approach to be a useful theory, the model must make clear the limits of these independent systems. Moreover, the argument is made that understanding the limits of each system is necessary to avoid the risk of a circular description of a dual route model of mental state understanding. One limit, according to Apperly and colleagues, on the cognitive efficient system is that it can support level-1 visual perspectives only and not level-2 visual perspectives or belief reasoning (Apperly, 2010; Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006; Back & Apperly, 2010). Surtees and Apperly (2012) suggested that cognitive efficiency in level-1 perspective taking is likely limited to *what* a person can see versus *how* something is seen demonstrating another limit of the efficient system.

Related to the limits of cognitive efficiency, Apperly considers the importance of processing speed. He points out that for mental state understanding to be successfully employed in social interactions it must occur fast enough. That is, the utility of social cognition for the facilitation of social interaction is that information processing must occur quick enough to be put to use. It is interesting to consider that slower processing speed in older adults might interrupt the ability of perspective taking to occur automatically. To be precise, if cognitive efficiency is limited by processing speed, then it is possible that older adult processing speed exceeds this limit. The hypothesis that the cognitive efficient system is limited by speed of processing requires further investigation.

Finally, an additional consideration is that the model as conceptualized by Apperly and colleagues overestimated the degree to which the automatic processes are free of executive resources. On the surface this appears to challenge the very argument of an automatic system; however, it is possible that the cognitively efficient system might at least involve some low-level executive resources. Schneider, Lam, Bayliss, and Dux (2012) designed a study to test if implicit theory of mind is influenced by executive control. Recall that the premise of a dual task design is to examine if one process (measured by a secondary task) interrupts a primary task. Schneider et al. (2012) found that implicit theory of mind (as measured by eye movement while participants watched a false belief scene) was disrupted under the dual task conditions suggesting that even implicit mental state representation involves some degree of executive resources. In terms of reconciling Schneider et al.'s results with the current study, several details must be pointed out. The significant task by perspective interaction in the current study indicated that the dual task was significantly more difficult compared to the alone task when older adults took their own perspective but not when they took the agent's perspective. Although it is unclear why the dual task appeared to increase cognitive load for self trials, the results from the current study suggest that the dual task did not increase cognitive load when participants made judgments based on the other perspective. This seems to indicate that taking another perspective does not involve inhibitory processes; however, the lack of altercentric interference effects in the current study suggests that taking the agent's perspective was not automatic for older adults. These two findings appear to be contradictory; however, it is possible that these seemingly divergent results are a consequence of the cognitively efficient system involving some low-level executive

resources. If the cognitively efficient system is not completely free from executive control, then older adults may not show evidence of the automatic processing due to their reduced executive resources. In other words, the reduced executive functioning of older adults may prevent the cognitively efficient system from being deployed. Alternatively, if the secondary task in the current study was not sufficiently difficult, then the executive resources may have not been taxed to a large enough degree to significantly impact the dual task. It is important to re-emphasize that no definitive conclusions can be made regarding the lack of altercentric effects in the current study. This is to say, it should be stressed that the null finding cannot be accepted as true and the disparate results require further investigation.

In considering the argument that the cognitive efficient system may recruit some low-level executive resources, then this may explain the dissimilar results of Schneider et al. (2012) and Qureshi et al. (2010). To review, in contrast to the results of Schneider et al. (2012), Qureshi et al.'s (2010) dual task did not disrupt automatic perspective taking. However, these two studies used different primary and secondary tasks. Schneider et al.'s (2012) primary task was tapping implicit theory of mind and verbal working memory was required for the secondary task. Qureshi et al.'s (2010) primary task required level-1 visual perspective taking and inhibitory control was required for the secondary task. The former study found evidence of disruption of an implicit theory of mind task whereas the latter study did not find evidence of disruption of implicit level-1 visual perspective taking. Two considerations come to mind when contrasting the results and task demands of these two studies. For one, several decades of evidence have demonstrated a strong relationship between theory of mind and verbal working memory.

Secondly, little is known about the task demands of the level-1 visual perpective taking. In fact, the current study was the first to examine the contribution of working memory on the level-1 visual perspective taking task developed by Samson et al. (2010). The dual task study designed by Qureshi et al. (2010) and the current study, are the only two studies that have examined how inhibition impacts level-1 visual perspective taking. Qureshi et al. (2010) found inhibition control did not interrupt automatic processes. The current study, however, did not find evidence of automatic processes in older adults; thus, inhibitory control in the current study is moot.

It seems plausible that these two abilities, implicit theory of mind and level-1 visual perspective taking, represented different degrees of cognitively efficient processes. In fact, as discussed earlier, Apperly (2010) suggested that level-1 but not level-2 visual perspective taking is cognitively efficient. Together, the results from Schneider et al. (2012) and Qureshi et al. (2010) suggest that implicit theory of mind may draw on working memory aspects of executive control while level-1 visual perspective taking involves fewer executive resources. However, there is not currently enough evidence to rule out the possibility that the cognitively efficient system related to level-1 visual perspective is completely free from executive resources. Finally, it also cannot be ruled out that the reason why older adults did not automatically process another agent's perspective is because of their decreased inhibition control compared to young adults.

The Role of Inhibition Control on Selection and Calculation

The third and forth hypotheses tested the effect of adding a secondary task to the primary level-1 perspective taking task. The secondary task recruited executive functioning resources, which was intended to specifically require inhibition control.

Thus, these hypotheses examined the role of inhibitory processes in level-1 perspective taking.

The third hypothesis investigated the role of inhibition during *selection* processes under the premise that inhibition is required when participants need to select between two possible perspectives (i.e., self or other perspective). In other words, in order to select the correct perspective, the alternate perspective would need to be inhibited. The task by consistency interaction tested the third hypothesis, with the prediction that inhibitory resources would be involved in selection processes. This hypothesis was grounded in the prediction that both alone and dual-task conditions would result in a consistency effect (i.e., inconsistent > consistent) with a significantly larger effect for inconsistent trials in the dual task compared to the alone condition; however no significant task by consistency interaction was found in the current study. Therefore, the current study provided no evidence regarding the role of inhibition during selection processes.

The final hypothesis relating to the level-1 visual perspective taking task tested the role of inhibition control on *calculation* processes. I hypothesized that participants would demonstrate a larger altercentric effect for the dual task compared to the alone condition. This hypothesis was grounded in the logic of a dual task design, which suggests that a secondary task will preclude a process involved in a primary task if the two tasks involve the same cognitive resources. In the case of the current study, if inhibition control were involved in the cognitive mechanisms underling the altercentric effect, then the secondary task would obviate the altercentric interference. As indicated by the significant interaction between consistency and perspective, however, no

altercentric effect was found in the current study. Therefore, the forth hypothesis was not supported.

Apperly (2010) suggested that since both children and adults are prone to making judgments about others based on their own perspectives (i.e., egocentric biases), this suggests that moving away from such biases requires cognitive effort. Based on the results from the current study, however, the role of inhibition control is unclear. In the current study, older adults were prone to egocentric interference, which is consistent with research suggesting that adults and children are prone to egocentric bias. On the other hand, the egocentric interference was not larger for the dual task condition, therefore there is no evidence regarding the role of executive functioning in terms of inhibition impacting the interference. In addition, no altercentric interference was found, thus the role of inhibition on automatic processing of other's perspectives could not be directly analyzed. To be clear, both of the hypotheses examining the role of inhibition were not supported; as a consequence, no inferences can be made regarding the role of inhibitory control aspects of executive functioning in level-1 visual perspective taking.

Even though the role of executive functioning when taking the agent's perspective could not be directly assessed, there is some evidence in the current study that taking another individuals' perspective does require cognitive effort for older adults. The follow-up analysis examining the significant interaction between perspective (i.e., self versus other) and task (i.e., alone versus dual) indicated that the dual task was significantly slower for the self perspective but there was no difference between the alone (999 ms) and dual-task conditions (1021 ms) for the other perspective. This suggests that taking the agent's perspective was equally challenging for older adults in the alone and

the dual task conditions, which may be the result of the other perspective being effortful for older adults to process. This is to say that for the current sample, it appears the other perspective was always effortful (i.e., equally effortful for both the alone and dual-task trials), whereas taking the self perspective was effortful for the dual task but not for the alone condition.

Gender Differences

When reaction time was used as dependent variable results indicated that males were overall faster than females on the level-1 visual perspective taking task. The effect size ($d = .73$) indicated that the gender effect of reaction time was moderate to large in magnitude (Cohen, 1988). No significant gender interactions were found, indicating that males and females did not differ in the relative performance on egocentric or altercentric interference effects. In addition, no differential gender differences were found for alone or dual-task conditions. Studies examining gender differences in reaction time consistently demonstrate that males respond significantly faster compared to females (e.g., Adam et al., 1999; Der & Deary, 2006). In addition to an overall reaction time advantage, males tend to demonstrate the greatest advantage on visual compared to auditory tasks (Spierer, Petersen, Duffy, Corcoran, & Rawls-Martin, 2010). Thus, the moderate to large gender effect in the current study might be partially due to the visual component of the perspective taking task.

The analysis using processing costs as the dependent variable did not reveal any gender effects. When considering that processing costs are calculated by dividing reaction time by the percent of correct trials, it appears that while males were faster than females, they were not more accurate than females. Previous research suggests that

gender differences in reaction time are partially a consequence of a speed-accuracy tradeoff; males are faster than females but the quicker speed comes with a cost of males being more error prone (Reimers & Maylor, 2006). In line with the speed-accuracy tradeoff, the results of the current study suggest that while males had the tendency to be faster than females, gender difference were diminished when accuracy was accounted for.

Summary

In summary, the main effect for consistency cannot be interpreted without first examining the significant interaction between consistency and perspective. Follow-up analyses indicated that there was a significant consistency effect for other but not for self conditions. Therefore, the current study found evidence that older adults were prone to egocentric but not altercentric interference effects. Thus, support for the first hypothesis was found but no evidence was found for the second hypothesis.

Following the logic of Qureshi et al. (2010), I differentiated between selection and calculation processes during the perspective taking task. The third hypothesis examined the role of inhibitory processes in *selection* processes, which was not supported as no interaction was found between task and consistency. This hypothesis would have been supported if both consistent and inconsistent conditions were slower for the dual task with inconsistent conditions disproportionately impacted. In regards to the forth hypothesis, which examined if executive functioning is involved in *calculation* processes (i.e., before a response is made), I hypothesized that dual-task trials would result in larger altercentric interference effects compared to the alone trials; however, the significant interaction between perspective and consistency indicated that no altercentric effect was found. Furthermore, an altercentric effect was not found in the alone or the dual-task

conditions (as would have been indicated by a three-way interaction between perspective, consistency, and task). Consequently, the forth hypothesis was not supported.

In regards to answering the first research question, the current study failed to find evidence of cognitively efficient processes in level-1 perspective taking in an older adult sample. The lack of evidence of older adults automatically processing the agent's perspective was considered from three viewpoints. First, it is possible that cognitively efficient perspective taking declines with age, which offers an explanation for the research that suggests that mental state understanding declines above and beyond domain-general cognitive processes. Second, Apperly (2010) asserted that one of the requisites of cognitive efficiency must be that there are limits to the capacity of the system; I suggested that age-related deficits in processing speed might impede cognitive efficiency in older adults. Finally, I considered the possibility that the automatic and cognitively efficient system may not be completely free from inhibition control. At this time, the veracity of these three hypotheses remains unknown.

**Theory of Mind, Level-1 Visual Perspective Taking,
and Working Memory**

Prior to discussing the results of the hierarchical regression, I will first discuss the current sample's performance on the working memory measures. Digit span from the Wechsler Adult Intelligence Scale–IV and symbol span from the Wechsler Memory Scale–IV were used as measures of verbal and spatial working memory respectively. The current sample means and standard deviations on the digit span forward, backward, and sequence were almost identical to a young adult sample in another study (n = 1600; Salthouse & Saklofske, 2010). The current sample means and standard deviation were 10.21 (2.28), 8.48 (1.85), and 8.86 (1.83) respectively. Salthouse and Saklofske (2010)

reported the following means and standard deviations for a young adult sample: 10.5

(2.4), 8.8 (2.5), and 8.7 (2.3) respectively. Furthermore, the mean symbol span score for

current study was 21.52 with a standard deviation of 5.51, which is comparable to the

mean of 21.04 and standard deviation of 8.7 from a large-scale study (n = 1399) of adults

aged 16-90 years old (Salthouse, 2009b). As previously discussed in chapter two, older

adults typically demonstrate greater variance compared to young adults; however, the

current sample preformed equivalent to young adult samples on the working memory

measures in terms of central tendency and variance.

**Theory of Mind and Working
Memory**

> H5   Verbal working memory will make a stronger contribution to performance
> on a theory of mind story task compared to spatial working memory.

The hierarchical regression analysis indicated that my fifth hypothesis was

supported. That is, verbal working memory contributed to theory of mind story

performance above and beyond spatial working memory. Although verbal working

memory contributed significantly to the model, only 12.8% of the theory of mind

variance was explained. Spatial working memory did not contribute significantly to the

model when it was added at the second step.

Overall, the model including both verbal and spatial working memory explained

15.4% of the variance. These results suggest that although verbal working memory does

impact older adult theory of mind performance, most of the variance was not accounted

for. Before considering other factors that may contribute to individual differences in

theory of mind performance in older adults, it should be noted that the research

examining the impact of working memory on age-related theory of mind declines to date has been equivocal.

McKinnon and Moscovitch (2007) found that older adults performed significantly worse than young adults on second order theory of mind but not first order theory of mind tasks. The authors analyzed the older adult error rates and found almost 70% were due their failure of considering multiple pieces of information. Additionally, participants made more errors on a theory of mind task when concurrently performing a secondary working memory task (i.e., a dual task) compared to when the theory of mind task was performed alone. The error rate analysis and dual task results from this study both suggest that theory of mind performance is mediated by working memory during aging.

In contrast, in a study that manipulated working memory demands on two theory of mind tasks, Sullivan and Ruffman (2004) found that older adults (m= 73 years old) performed significantly worse than younger adults on both tasks; that is, older adults still showed theory of mind impairments even when working memory demands were reduced. Based on these results, Sullivan and Ruffman argued that theory of mind abilities decline in older adults independent of working memory and general cognitive abilities. Other studies have also found that older adults perform worse on both theory of mind and control stories (German & Hehman, 2006; Slessor, Phillips, & Bull, 2007), which suggests that observed performance declines are not specifically associated with understanding mental states but are instead associated with cognitive functioning.

In addition to working memory, previous research has demonstrated that inhibition control plays a role in mental state understanding in older adults (e.g., Duval et al., 2011; Charlton et al., 2009). German and Hehman (2006) found that older adult

performance on reasoning about other's beliefs correlated with inhibitory control, working memory, and processing speed. Systematic increases in inhibition demands resulted in performance declines for both young and older adults; however, older adults were disproportionately worse than younger adults on tasks with higher inhibition control demands.

It should be noted that the association between theory of mind and working memory and inhibition has been demonstrated in developmental and young adult samples. Research suggests that during the preschool years inhibitory control (e.g., Carlson, Mandell, & Williams, 2004; Carlson, Moses, & Breton, 2002; Hala, Hug, & Henderson, 2003) and working memory (Mutter, Alcorn, & Welsh, 2006) critically impacts theory of mind performance. Individual differences on theory of mind story tasks in young adult samples also has been demonstrated to be driven, at least in part, by working memory (Bull, Phillips, & Conway, 2008; Stone, Baron-Cohen, & Knight, 1998). For instance, Lin, Keysar, and Epley (2010) found that adults with low working memory capacity were significantly worse at making mental state attributions than adults with high working memory capacity. These results suggest that working memory is an important executive capacity for explicit theory of mind performance in development as well as through older adulthood. However, the current study did not examine young adults performance and did not examine executive components beyond working memory thus, these two issues cannot be directly assessed in the current study.

Collectively, an examination of the literature to date as well as the results from the current study suggest that although working memory does mediate theory of mind performance in older adults, there are other factors that contribute to individual

differences in theory of mind during aging. It is possible that some of the studies did not find evidence of working memory contributing to older adults theory of mind performance because only a small amount of variance is explained by working memory. Most the studies have used small sample sizes (e.g., n = 24 older adults, Sullivan & Ruffman, 2004), which reduce the power to detect a small effect of working memory on theory of mind performance. Furthermore, many of the studies have used a small number of items to measure theory of mind performance in older adults (e.g., German & Hehman, 2006; Maylor et al., 2002). The current study addressed these issues by including a sample size of 42 older adult participants and 20 items from the strange stories task (i.e., 10 items for the theory of mind stories and 10 items for the control stories).

**Level-1 Visual Perspective Taking
and Working Memory**

H6 Spatial working memory will make a stronger contribution to performance on a level-1 visual perspective taking task compared verbal working memory.

Participants completed the level-1 visual perspective taking task alone and as a dual task. Accordingly, two hierarchical regression analyses were conducted that examined the role of working memory on each of the outcome variables (i.e., processing costs for the alone task and processing costs for the dual task). Both hierarchical regression analyses indicated that neither spatial nor verbal working memory contributed to the model significantly. Thus, the current study did not find evidence of the role of working memory on level-1 visual perspective taking performance.

No previous studies have examined the contribution of working memory on level-1 visual perspective taking task developed by Samson et al. (2010). I predicted that spatial working memory would explain level-1 visual perspective taking above verbal

working memory based on an informal assessment of the task demands. To complete the task, participants must keep in mind two pieces of information. That is, participants must remember the perspective (i.e., self or other) and then the number (i.e., 0, 1, 2, or 3) indicated on the computer screen to be able to give an accurate response. Moreover, these two stimuli are presented for only 750 ms and participants cannot go back to view these stimuli once they have been presented. In addition, since the task is visual and includes a spatial component regarding the location of the red dots on the walls, I examined the role of both spatial and verbal working memory on performance. In the current study, symbol span was used to measure spatial working memory since it assesses both the storage and manipulation of visual stimuli. In consideration of the requirements of the task, I predicted that spatial working memory would explain level-1 visual perspective taking above verbal working memory. Additionally, when considering that two stimuli are presented successively and participants are required to subsequently use that information to make a response, I was also interested in examining if verbal working memory would make a contribution to the model. The current study, however, does not indicate that spatial or verbal working memory contributes to level-1 visual perspective taking in older adults.

These results strengthen the utility of using this task as a measure of automatic perspective taking. Nevertheless, it should be emphasized that the specific feature that is assumed to measure automatic processing is a contrast between consistent and inconsistent trials for self perspective conditions. Rather than measuring automatic processes directly, an automatic mechanism is inferred by examining the relative difference between consistent and inconsistent trials. As a result, even if working

memory did contribute to individual differences on level-1 visual perspective taking, the automatic component of the task would still be compelling if an altercentric effect was found.

In comparing the task demands of level-1 visual perspective taking with theory of mind stories, it is not surprising that these two tasks do not involve the same working memory demands. Still, prior to the current study, the working memory demands of level-1 visual perspective taking had not been explored. The results from the current study indicated that level-1 visual perspective taking did not load on working memory while theory of mind performance did; this illustrates the usefulness of these tasks as tapping different components of mental state understanding. Specifically, the disassociation between these two tasks strengthens the case for conceptualizing level-1 visual perspective taking as containing relatively more implicit processes compared to the theory of mind task, which involves relatively more explicit processes.

Limitations

The current study has several limitations that should be considered when interpreting the results. First, even though an aging in place sample was obtained with the goal of increasing the generalizability of the results, purposeful non-probability sampling methods were used. Therefore, there are limits of the generalizability of the sample to the wider population of older adults. Examining the demographics of the current sample gives another indication that the results may not generalize to the broader population. For example, the careers reported by the participants include engineers, college faculty, computer programmers, and a physician (Appendix D). In addition, as indicated by self-report, the sample was highly educated. It is plausible that the

intelligence of the current sample was skewed to the right hand tail of the normal distribution (i.e., negative skew); however, no measure of intelligence was obtained thus, intellectual ability was not controlled for in the current study. In addition, the sample was not screened for mild cognitive impairment; therefore, it is unknown if the sample in the current study contained individuals who have symptoms of mild cognitive impairment.

In regards to the level-visual perspective taking task, three limitations come to mind. First, since no young adult sample was obtained in the current study caution is needed when making inferences regarding age-related performance. All discussions regarding contrasting age differences have been made based on three prior studies and thus no direct contrast is available in the current study. Second, it is possible that the dual task was not sufficiently difficult for the older adult sample. Interestingly, the participants verbalized how challenging they felt the task was; however, when examining the alone compared to the dual task conditions, little evidence is present that the dual task adequately increased cognitive load. Even though the secondary task employed in the current study was designed to tap inhibition control, there is the possibility that it was not as difficult as the dual task used by Qureshi et al. (2010) or requires different underlying mechanisms. The secondary task used by Qureshi et al. (2010) required that participants tapped a box in the opposite direction of the number of tones that they heard. That is, participants tapped once if they heard two tones and vice versa. It is possible that the number of disks presented in the primary task and the number of tones presented in the secondary task was a confound that increased the working memory load in addition to the inhibitory demands during the dual task. In the current study, the confounding variable

regarding the numerical aspect of the stimuli in the primary and secondary tasks was removed; thus, the dual task employed in the current study cannot be directly compared to the dual task used by Qureshi et al. Third, the secondary task in the current study may not tap the same inhibitory processes that are involved in the perspective taking task.

In terms of the hierarchical regression results, two limitations should be considered when interpreting the results. First, the range of variance in the criterion and predictor variables were relatively low. The theory of mind story task had a mean of 15.48 (out of a 20 points possible) with a standard deviation of 2.54; however, there were three outliers with low scores that were disconnected from the rest of the distribution. The mean and standard deviation of the theory of mind story task with these three outliers dropped are 16.03 and 1.75, indicating that the variance for the majority of the distribution was small. Secondly, the older adults in the current sample performed more typical of a young adult sample on the working memory measures. As discussed in chapter two of the current study, older adults typically have wider variability compared to young adults; however, the currents sample did not display this pattern. If the current sample is more homogenous compared to the population (i.e., low amount of variance for the current sample is an artifact of the current study) then it is possible that there was reduced statistical power to detect the role of working memory on the level-1 perspective taking task. That is, the low amount of variance for the current sample could have limited the statistical power to detect associations between variables.

Future Research

With the goal of examining age-related differences in mental state understanding, it would be important to compare the results from the current study to a young adult

sample. Thus, the first recommendation for future research is to employ the same method used in the current study with a young adult sample. In this way, an age comparison can be made for both the level-1 visual perspective taking and the theory of mind story task.

In obtaining a young adult sample, the first question would be to examine if young adults display egocentric and altercentric interference effects using the level-1 visual perspective taking task as reported in previous research (Samson et al.,2010; Surtees & Apperly, 2012; Qureshi et al., 2010). Although there is no reason to believe that the findings would differ from the previous three studies using young adult samples, it would be valuable to obtain data from a young adult sample for a direct comparison. If results from a younger adult sample mimic that of the previous studies conducted by Apperly and colleagues, then this would provide further evidence that automatic processes decline with age.

With the addition of a young adult sample, it would be interesting to examine if older adults demonstrate larger egocentric interference compared to young adults. Previous research suggests that older adults are more prone compared to young adults to egocentric errors (Inagaki et al., 2002). Egocentric interference in the level-1 visual perspective taking task is indicated by larger processing costs for inconsistent compared to consistent trials when judging the other perspective. Currently, it is unknown if age-related changes in egocentric interference would be demonstrated on the level-1 visual perspective taking task. Finally, with a young adult sample, I recommend comparing older adult performance to young adult performance on the day night task. German and Hehman (2006) found that older adults did not perform significantly worse compared young adults in a version of a day night task. Using an inhibition task that does not

demonstrate age-related decline would be ideal in terms of controlling for the difficulty of the secondary task for both groups.

The next recommendation for future research is to further investigate gender differences on the level-1 visual perspective taking task. The current study found that males were significantly faster compared to females as indicated by an overall gender effect. No significant gender interactions were found; however, when including gender as a between factor variable, and considering the number of conditions in the ANOVA (i.e., 2 x 2 x 2 x 2), the sample size in the current study is low. A power analysis was conducted for a mixed design (i.e., using within-subjects and between-subjects variables) using G*Power 3.1 software (Faul, Erdfelder, Lang, & Buchner, 2007). With a medium effect size ($\eta_p^2 = .3$), alpha set to .05, power set to .95, and the correlation between repeated measures set to .7, a sample size of 52 (26 males and 26 females) would be necessary. Therefore, an additional 10 more participants should be collected to adequately examine gender interactions.

In terms of examining gender, an interesting trend was found for the interaction between perspective (i.e., self versus other) and consistency (i.e., consistent versus inconsistent). There was a tendency for females but not males to be slower for the inconsistent compared to the consistent trials for the Self perspective (i.e., females but not males trended towards an altercentric interference effect). In contrast, both males and females were significantly slower for the inconsistent compared to the consistent trials for the Other perspective (i.e., demonstrating an egocentric interference effect). Even though no significant gender interactions were present in the current study, females demonstrated a 113 ms advantage in the consistent compared to inconsistent trials for the Self

perspective; whereas, males did not show any difference between inconsistent and consistent trials for the Self perspective. It should be reemphasized that this gender interaction was not statistically significant, which indicates that although females were numerically slower for inconsistent compared to consistent trials, females did not demonstrate a significant altercentric interference effect. The previous three studies that used this task (Samson et al., 2010; Surtees & Apperly, 2012; Qureshi et al., 2010) did not report gender results, therefore it is unclear whether no gender differences were found in the prior studies or if the researches did not examine gender (See Figures 9 and 10 for an illustration of this gender trend).

It is interesting to consider the possibility that females may be prone to altercentric interference effects while males may not be. This finding would be consistent with research that has found gender differences in other areas of social cognition. For instance, previous research suggest that females demonstrate enhanced eye gaze cueing effects (Bayliss, Pellegrino, & Tipper, 2005), are more accurate in face emotion recognition (Hoffmann, Kessler, Eppel, Rukavina, & Traue, 2010) and reading nonverbal behavior (Hall, 1978), and are more sensitive to gleaning information from eyes (Kirkland, Peterson, Baker, Miller, & Pulos, 2013) compared to males. Thus, it would be noteworthy to examine this three-way interaction (i.e., perspective by consistency by gender) with a larger sample size.
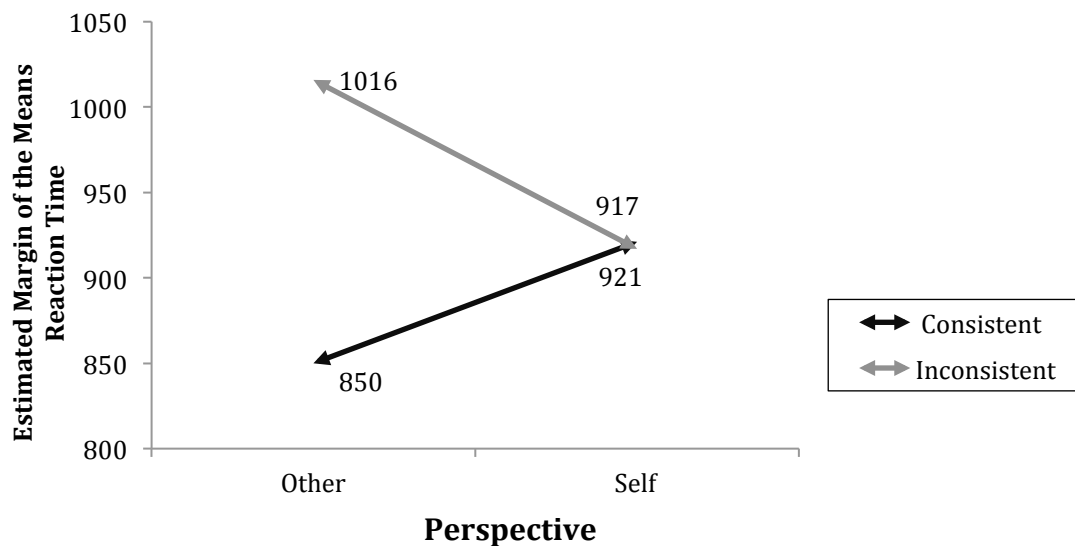
Figure. 9. Line Graph of the Perspective by Consistency Interaction for Males. Notes: This illustrates a signfiant consistency effect for the Other but not Self perspective, which corresponds to an egocentric but not an altercentric interference effect.
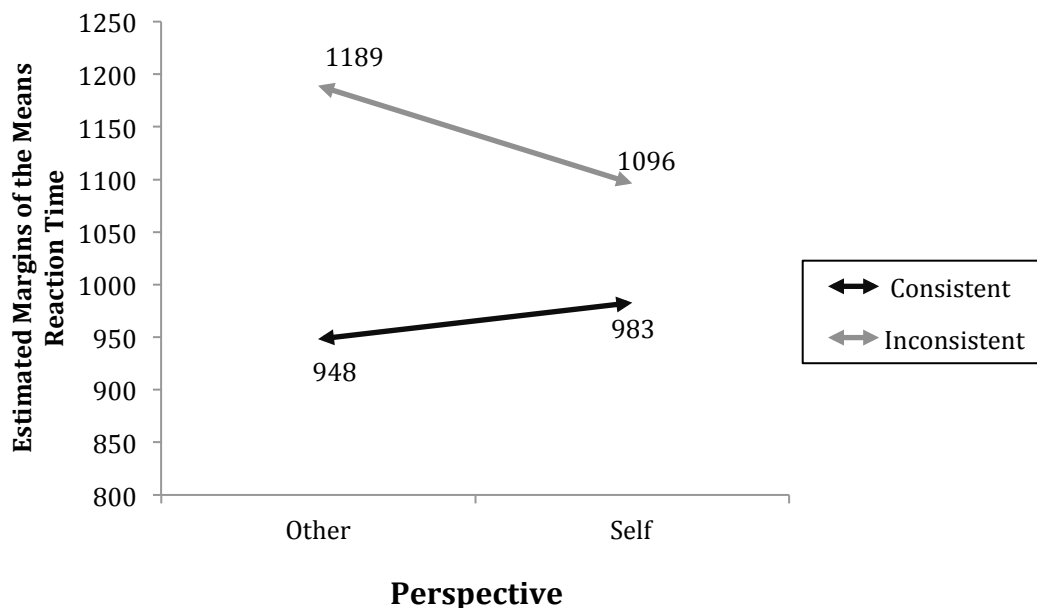
Figure. 10. Line Graph of the Perspective by Consistency Interaction for Females. Notes: This illustrates the signfiant consistency effect for Other perspective and a trend towards a consistency effect for Self perspective. This corresponds to an egocentric effect and a trend towards an altercentric interferene effect; however, the latter was not significant.

The final recommendation for future research is to replicate the current study using a different sample of older adults. In the current study, the lack of evidence of older adults automatically processing other people's perspectives will only be substantiated if theses findings are replicated. Furthermore, if the findings do replicate, then it would be advised to investigate possible explanations regarding the mechanisms of such age-related changes. That is, if future evidence supports differential automatic processes related to mental state understanding in young compared to older adults, then the sources of age-related change should be investigated.

Apperly proposed that examining the limits of the cognitive efficient system is essential to understanding the dual route model of mental state understanding. Earlier I suggested that speed of processing might be a possible limit of the cognitively efficient system. Although I presented an argument that the lack of evidence of automatic processes in older adults might be due to a processing speed limit, this hypothesis requires further investigation. One recommendation is to collect processing speed data and run a hierarchical regression with processing speed as a predictor variable and level-1 visual perspective taking as the outcome variable.

Apperly (2011) has suggested that the role of working memory and inhibition may disproportionally impact older adults performance on explicit theory of mind tasks (e.g., German & Hehman, 2006; McKinnon & Moscovitch, 2007). In the current study, verbal working memory made a statistically significant contribution to explaining theory of mind performance, as measured by the Strange Stories Task, however, a large degree of variance remained unaccounted for. Previous research suggests that other executive processes are related to theory of mind performance, such as inhibition control (Charlton

et al., 2009; Duval et al., 2011) and processing speed (German & Hehman, 2006). In the current study, measures of inhibition control and processing speed were not obtained; thus, these executive processes could not be examined. It would be useful to conduct two hierarchical regressions with measures of inhibition control and speed of processing as the predictor variables and both the level-1 visual perspective taking and theory of mind story tasks as the outcome variables. Reaction time data from the Day-Night task that was employed for the current study (i.e., the secondary task that was used for the dual task level-1 visual perspective taking task) would be easy to obtain as a measure of inhibition. Furthermore, it would be interesting to compare the variance explained by inhibition in young and older adult samples. Based on the robust evidence of age-related decline in inhibitory control, I would hypothesize that individual differences on the Day-Night task would mediate performance on the level-1 visual perspective taking task to a larger degree in an older adults compared to a young adults. In addition, since the current study was the first to examine the association of working memory on level-1 visual perspective taking, it would be useful to replicate the hierarchical regression analysis using the same tasks that were conducted in the current study as well as to include additional working memory measures.

Conclusions

The current study examined mental state understanding in an aging sample from a cognitive perspective. Previous research suggests that children and adults spontaneously process other individual's perspectives (Samson et al., 2010; Surtees & Apperly, 2012; Qureshi et al., 2010). Additionally, a significant amount of research also suggests that some aspects of mental state understanding involve explicitly mediated processes (e.g.,

Dunn & Brophy, 2005; Milligan, Astington, & Dack, 2007). For instance, researchers have reported individual differences in mental state understanding are related to working memory (e.g., Lin et al., 2010) and executive functioning (e.g., Sabbagh et al., 2006). Aging is associated with cognitive decline in three areas that are also linked to explicit mental state understanding: processing speed, executive functioning, and working memory (Charlton et al., 2009). Therefore, when investigating mental state understanding during the aging process, the cognitive resources that are associated with mental state understanding must be taken into consideration (Moran, 2013). The primary goal of the current study was to examine cognitively efficient and cognitively effortful processes involved in mental state understanding during aging.

Two tasks were used to investigate mental state understanding in older adults, which differ in the degree to which they involve implicit versus explicit processes. At a basic level, mental state understanding involves perceptual processing of another individual's visual perspective (Flavell, Everett, Croft, & Flavell, 1981). A level-1 visual perspective taking task was used to investigate if older adults demonstrate evidence of taking another individuals perspective relatively automatically. To examine if taking another individuals perspective is cognitive efficient, a dual task version of the level-1 visual perspective taking task was used. A theory of mind story task measured explicit mental state understanding in older adults. Finally, a hierarchical regression was conducted to examine the contribution of spatial and verbal working memory on both the level-1 visual perspective taking and theory of mind story tasks.

The current study, failed to find evidence that older adults automatically take another agent's perspective using a level-1 visual perspective taking task. In contrast,

the evidence in the current study suggests that processing a perspective that differs from one's own perspective is cognitively effortful. These findings were based on the evidence that older adults suffered from egocentric but not altercentric interference effects. Evidence from three previous studies demonstrated that taking the visual perspective of another individual involves relatively automatic processes (Samson et al., 2010; Surtees & Apperly, 2012; Qureshi et al., 2010). Three possible explanations were presented regarding the lack of evidence of older adults automatically processing another individual's visual perspective.

One possible explanation regarding the lack of evidence in the current study of automatic processes in level-1 visual perspective taking is that cognitive efficient processes may decline during aging. While there is a substantial amount of evidence that suggests explicit mental state understanding does decline with age, there is no *a priori* reason to believe that relatively implicit mental state understanding would be impervious to decline. Hence, the evidence from the current study does not necessarily diverge from the larger literature suggesting a dissociable system for understanding other's mental states. Certainly, if older adults showed evidence of intact automatic and cognitively efficient system, then this would provide evidence in support of the dual route model in terms of a double disassociation. However, the evidence that the fast and automatic system may decline with age does not inevitably threaten the theoretical assumptions of the dual route for mental state understanding.

Gender was examined in the level-1 visual perspective taking task. Results indicated that males performed significantly faster than females and no significant gender interactions were found; however, there was a trend for females but not males to be prone

to altercentric interference effects. I suggested that future research further examine possible gender interactions on this task. The overall faster reaction times for males compared to females aligns with the broader literature, which suggests that across the adult lifespan that males respond significantly faster on reaction time measures compared to females (e.g., Adam et al., 1999; Der & Deary, 2006).

With the burgeoning field of social cognitive science and the recognition that mental state understanding is central to social communication, researchers have investigated mental state understanding in a wide range of contexts and populations (Saxe & Baron-Cohen, 2006). One corner of this research has examined mental state understanding during the aging process. To date, an accumulation of research suggests that mental state understanding deteriorates during normal aging (Henry et al., 2012; Moran, 2013); however, the mechanism underlying the age-related decline is unclear. The current study was the first to examine both cognitively efficient and cognitively effortful processes in an older adult sample. No evidence was found of cognitively efficient processes relating to level-1 visual perspective taking in the current study. In addition, the current study examined if individual differences in working memory contributes to theory of mind and level-1 visual perspective taking performance. Results indicated that a small portion of theory of mind variance was explained by verbal but not spatial working memory. Neither verbal nor spatial working memory contributed to level-1 visual perspective taking performance. When considering the literature to date, it seems the degree to which automatic versus effortful mechanisms are involved depends on the specific context that mental state understanding is employed. In terms of mental state understanding during aging, the current study provides no evidence that older adults

automatically process another agent's perspective. However, further research is

necessary before any conclusions can be made. In addition, since verbal working

memory only explained a small degree of variance in the theory of mind story task, future

research is recommended to investigate the impact of other executive processes that may

contribute to explicit mental state understanding during the aging process.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY *of*
NORTHERN COLORADO

Institutional Review Board

DATE: July 15, 2013

TO: Rena Kirkland
FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [474154-2] Mental State Understanding in Older Adults
SUBMISSION TYPE: Revision

ACTION: APPROVED
APPROVAL DATE: July 15, 2013
EXPIRATION DATE: July 15, 2014
REVIEW TYPE: Expedited Review

Thank you for your submission of Revision materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of July 15, 2014.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

Rena -

APPENDIX B

CONSENT FORM

UNIVERSITY *of*
NORTHERN COLORADO

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Mental State Understanding in Older Adults
Researcher: Rena Kirkland, Educational Psychology Ph.D. Student
                          E-mail: Thom6071@bears.unco.edu

Advisor: Marilyn Welsh, Ph.D., Psychological Sciences
Phone: (970) 351-2263   E-mail: Marilyn.Welsh@unco.edu

Purpose and Description: The primary purpose of this study is to explore social cognitive processes in older adults. Social cognition includes a wide range of mental processes related to social interactions. For example, how we think about other people, judge other people's emotions and perspectives, and interpret social interactions are various aspects of social cognition. In the current study, we are interested in examining two different aspects of social cognition. We are also interested in how general cognitive ability, such as performance on a vocabulary test, is related to social cognition.

Participating in this study will consist of completing the following tasks:
- Responding either "yes" or "no" to a computerized task asking about how many dots either you can see or the "cartoon" person can see
- Responding with a press to a computer mouse after a voice says "day" or "night"
- Reading short stories about the interaction of two people and answer questions regarding the intentions of the characters in the stories
- Examining photographs of eyes and choosing one word (from of four possible words) that best describes the associated set of eyes
- Verbally responding to a list of numbers repeated exactly, repeated backwards, and repeated in ascending order
- Examining pictures of shapes and then identifying the correct shapes that were previously viewed in the correct order

A 10-dollar gift certificate will be offered to you as a token of our appreciation for participating in this study. It is estimated that the data collection described above will take 90 minutes to complete; however, you are free to stop this study before the completion of the tasks. That is, you are free to withdraw from the study for any reason at any time.

Every precaution will be taken to protect confidentiality. A participant number will be assigned to you. The only identifying information is this consent form, which will be filed separately from the data. That is, your participant number will not be connected to your name on this consent form. Data collected and analyzed for this study will be kept in a locked cabinet in the College of Psychological Sciences at the University of Northern Colorado.

Potential risks in this project are minimal. It is possible that some of the cognitive tests will be perceived as stressful. In addition, you will be taking time out of your daily life to participate in this study. As a small token of appreciation, a 10-dollar gift certificate will be offered to you even if you decide to not complete the study.

It is important that you feel comfortable regarding the purpose of this study and what participation involves. Please take this opportunity to ask the researcher any questions you have regarding any aspects of this study.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-2161.

_____

Subject's Signature   Date

_____

Researcher's Signature

APPENDIX C

INSTITUTIONAL REVIEW BOARD AMENDMENT
APPROVAL LETTERS

Please note that University of Northern Colorado (UNCO) IRB has published the following Board Document on IRBNet:

Project Title: [474154-3] Mental State Understanding in Older Adults
Principal Investigator: Rena Kirkland

Submission Type: Amendment/Modification
Date Submitted: July 16, 2013

Document Type: Approval Letter
Document Description: Approval Letter
Publish Date: July 17, 2013

Should you have any questions you may contact Megan Babkes Stellino at megan.stellino@unco.edu.

Thank you,
The IRBNet Support Team

UNIVERSITY *of*
NORTHERN COLORADO

Institutional Review Board

DATE: August 8, 2013

TO: Rena Kirkland
FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [474154-4] Mental State Understanding in Older Adults
SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVED
APPROVAL DATE: August 8, 2013
EXPIRATION DATE: July 15, 2014
REVIEW TYPE: Expedited Review

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of July 15, 2014.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

Thank you for a clear explanation of your revisions. Best wishes with your research.

Dr. Megan Stellino, UNC IRB Co-Chair

Generated on IRBNet

APPENDIX D

SELF REPORT DEMOGRAPHIC CHARACTERISTICS
OF SAMPLE

Table 13

Demographic Characteristics of Sample as Measured by Self-Report

		Frequencies	Percentag
Martial Status			
	Never	2	4.8 %
	Divorced	1	2.4 %
	Widowed	5	11.9 %
	Living with significant other	33	78.6 %
Retired			
	No	9	22.5 %
	Yes	31	77.5 %
Exercise			
	Never	6	14.3 %
	Seldom	6	14.3 %
	Sometimes	11	26.2 %
	Often	18	42.9 %
Health			
	Poor	0	0
	Fair	3	7.7
	Good	16	41.0
	Excellent	20	51.3
Computers			
	Poor	1	2.5
	Fair	6	15.0
	Good	17	42.5
	Excellent	16	40.0
Part-time work			
	No	32	78.0
	Yes	9	22.0
Full-time work			
	No	38	92.7
	Yes	3	7.3
Volunteer			
	No	29	70.7
	Yes	12	29.3
Homemaker			
	No	35	83.3
	Yes	7	16.7

Table 14

Careers of the Sample

Careers of participants
Certified public accountant
College professor
Computer programmer
Consulting
Business professor
Electrical engineer
Elementary school teacher
Estimator of awnings
Faculty in computer engineering
Fitness monitor
Foreign policy
Golf course ranger
Hairdresser & Nurse
Personal fitness trainer
Physical therapist
Physician
Real estate appraisals
Seamstress
Software development
Transcription business for law firm
Writer/musician

APPENDIX E

DEMOGRAPHICS FORM

Demographics

1.   Gender: □ Male □ Female

2.   Age: _____

3.   As of today, what is your current marital status? Pick one of the following:

□ Never married or partnered

□ Divorced

□ Widowed

□ Living or married with significant other

4.   Over the past seven days, how often did you engage in
sport and/or recreational activities such as jogging, cycling, swimming, singles
tennis, aerobic dance, skiing, or other similar activities? Pick one of the
following:

□ Never

□ Seldom (1-2 days)

□ Sometimes (3-4 days)

□ Often (5-7 days)

5.   How would you rate your perceived health? Pick one of   the following:

□ Poor

□ Fair

□ Good

□ Excellent

6.   How would you rate your comfort level with computers?
□ Poor
□ Fair
□ Good
□ Excellent

7.   How many years of education do you have, including any college? _____

8.   Occupation: (check all that apply)

□ Currently retired
        If yes, since what year _____
□ Full-time homemaker
□ Volunteer
□ Employed full-time**
□ Employed part-time**

** If you are currently employed full or part-time, what kind of work do you do?

_____

APPENDIX F

INSTRUCTIONS FOR LEVEL-1 VISUAL
PERSPECTIVE TAKING TASK

F_version (right-handed)

Thank you for participating in this study!

You will see a room with a woman inside.
On the left and right walls, there are sometimes red circles pinned on the wall.
Here is an example:
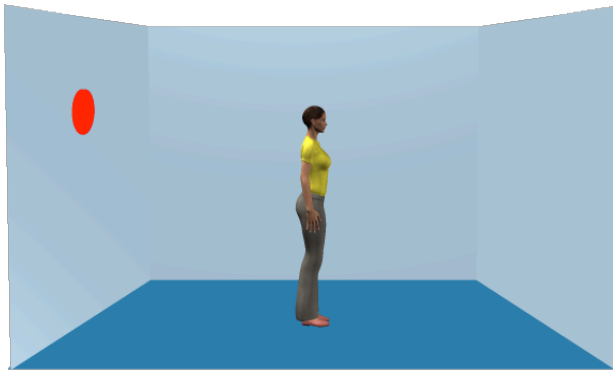
On half of the trials, you will respond to how many circles <u>you</u> can see from your perspective.

On the other half of the trials, you will respond to how many circles the <u>woman</u> can see from her perspective.

During the experiment you will see the following sequence of events:

1) a plus sign
2) the words YOU or SHE
3) a number between 0 and 3
4) the picture of the room → This is where you will make a "yes" or "no" response
   - Answer **yes**, when the number of circles matches the perspective you were told to take (i.e., YOU or SHE)
   - Answer **no**, when the number of circles does not match the perspective you were told to take (i.e., YOU or SHE)

5) After your response, you will be given a feedback ("Correct" or "Wrong")

It is important that you try to respond **<u>as quickly and accurately as possible.</u>**

We will start with a practice block. Then, there will be 2 test blocks and one more practice block. In between the blocks, you can take a break.

As a reminder, try to respond **<u>as quickly and accurately as possible</u>**.

Thanks again for your participation!

Here are two examples
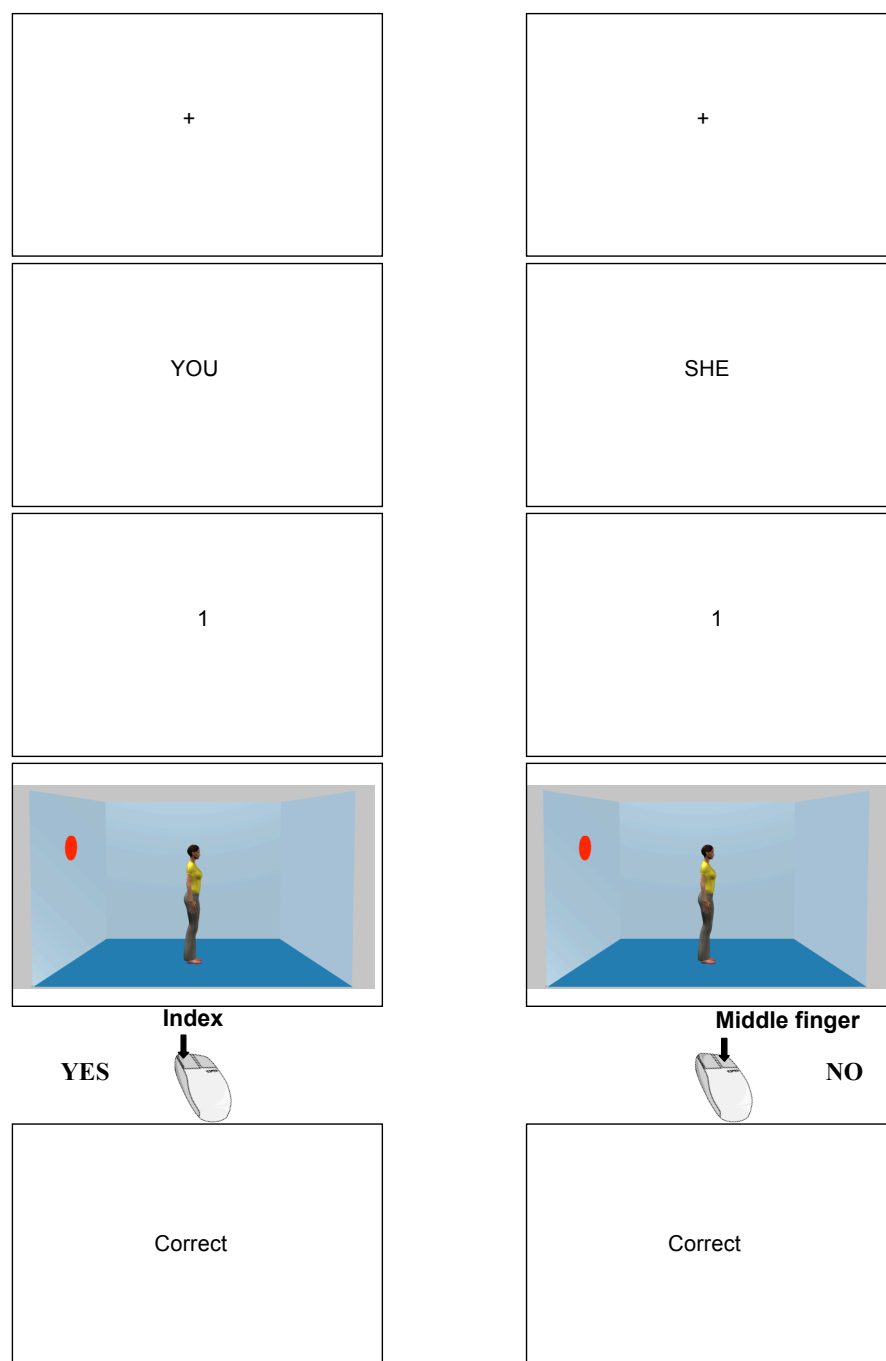

Figure. 5. Participants Viewed the Following Image Accompanied Verbal Instructions

APPENDIX G

DISTRIBUTION STATISTICS FOR LEVEL-1 VISUAL
PERSPECTIVE TAKING

Table 15

Distribution Statistics for Level-1 Visual Perspective Taking: Processing Costs without Transformations

	n	Shapiro-Wilk		Skewness		Kurtosis	
		Statistic	Sig.	Statistic	SE	Statistic	SE
Alone							
Other Consistent	40	.901	.002	.928	.369	.037	.724
Other Inconsistent	40	.741	.000	2.448	.369	6.480	.724
Self Consistent	40	.890	.001	1.255	.369	1.739	.724
Self Inconsistent	40	.798	.000	1.810	.369	3.380	.724
Dual							
Other Consistent	40	.731	.000	1.726	.374	3.136	.733
Other Inconsistent	40	.824	.000	2.238	.369	5.936	.724
Self Consistent	40	.756	.000	2.894	.369	10.239	.724
Self Inconsistent	40	.810	.000	2.542	.369	6.904	.724

Note. SE = Standard Error; Skewness should be $< \pm 2$; Kurtosis should be $< \pm 3$

Table 16

Distribution Statistics for Level-1 Visual Perspective Taking: Processing Costs after Transformations

	n	Shapiro-Wilk		Skewness		Kurtosis	
		Statistic	Sig.	Statistic	SE	Statistic	SE
Alone							
Other Consistent	40	.948	.058	.557	.369	-.522	.724
Other Inconsistent	40	.902	.002	1.166	.369	1.674	.724
Self Consistent	40	.964	.222	.583	.369	-.039	.724
Self Inconsistent	40	.920	.007	.979	.369	.455	.724
Dual							
Other Consistent	40	.935	.021	1.075	.369	1.566	.724
Other Inconsistent	40	.952	.086	.464	.374	1.141	.733
Self Consistent	40	.937	.025	1.001	.369	1.458	.724
Self Inconsistent	40	.911	.004	1.290	.369	2.436	.724

Note. SE = Standard Error; Skewness should be $< \pm 2$; Kurtosis should be $< \pm 3$

Table 17

Distribution Statistics for Level-1 Visual Perspective Taking: Reaction Time without Winsorizing

	n	Shapiro-Wilk Statistic	Sig.	Skewness Statistic	SE	Kurtosis Statistic	SE
Alone							
Other Consistent	40	.901	.002	.93	.37	.04	.72
Other Inconsistent	40	.741	.000	2.45	.37	6.48	.72
Self Consistent	40	.890	.001	1.26	.37	1.74	.72
Self Inconsistent	40	.798	.000	1.81	.37	3.38	.72
Dual							
Other Consistent	40	.731	.000	2.55	.37	8.62	.72
Other Inconsistent	40	.824	.000	1.73	.37	3.14	.73
Self Consistent	40	.756	.000	2.24	.37	5.94	.72
Self Inconsistent	40	.810	.000	2.89	.37	10.24	.72

Note. SE = Standard Error; Skewness should be < ± 2; Kurtosis should be < ± 3

Table 18

Distribution Statistics for Level-1 Visual Perspective Taking: Reaction Time after Winsorizing

	n	Shapiro-Wilk Statistic	Sig.	Skewness Statistic	SE	Kurtosis Statistic	SE
Alone							
Other Consistent	40	.950	.073	.560	.369	-.188	.724
Other Inconsistent	40	.944	.046	.566	.369	.575	.724
Self Consistent	40	.958	.148	.398	.369	-.619	.724
Self Inconsistent	40	.925	.012	.733	.369	-.339	.724
Dual							
Other Consistent	40	.907	.003	.978	.369	.473	.724
Other Inconsistent	40	.957	.136	.660	.374	.909	.733
Self Consistent	40	.907	.003	.957	.369	.114	.724
Self Inconsistent	40	.964	.232	.398	.369	-.669	.724

Note. SE = Standard Error; Skewness should be < ± 2; Kurtosis should be < ± 3

APPENDIX H

DISTRIBTUTION STATISTICS FOR THEORY OF MIND
AND WORKING MEMORY MEASURES

Table 19

Distribution Statistics for Theory of Mind Story Task, Verbal and Spatial Working Memory

	n	Shapiro-Wilk Statistic	Sig.	Skewness Statistic	SE	Kurtosis Statistic	SE
SST							
Theory of mind	42	.896	.001	-1.110	.365	2.104	.717
Control stories	42	.938	.024	-.427	.365	-.602	.717
Digit span total	42	.964	.213	.461	.365	.437	.717
Digit span forward	42	.962	.171	.436	.365	-.327	.717
Digit span backward	42	.892	.001	1.166	.365	2.296	.717
Digit span sequence	42	.958	.127	-.155	.365	-.527	.717
Symbol span	42	.986	.883	-.102	.365	-.359	.717

Note. SST = Strange stories Task, which includes theory of mind stories and control stories (Happé, 1994); SE = standard error; Digit span is a measure of verbal working memory and symbol span is a measure of visual working memory from the Wechsler Adult Intelligence Scale-IV (Wechsler, 2008); Skewness should be < ± 2; Kurtosis should be < ± 3

APPENDIX I

STATISTICS FOR LEVENE'S TEST OF EQUAL ERROR
VARIANCES FOR THE ANALYSIS OF VARIANCE

Table 20

Levene's Test for Equality of Variance for the Mixed-design ANOVA

Condition	F-test	p-value
Alone		
Other consistent	.572	.454
Other inconsistent	.155	.696
Self consistent	.421	.520
Self inconsistent	8.023	.007
Dual		
Other consistent	1.803	.187
Other inconsistent	.004	.952
Self consistent	.233	.632
Self inconsistent	3.742	.061

Note. Levene's test is not considered a threat to equal variance unless the p-value is < .001; thus, all variables meet the assumption of homogeneity of variance.

APPENDIX J

DESCRIPTIVE STASTICS FOR LEVEL-1 VISUAL
PERSPECTIVE TAKING TASK: PROCESSING
COSTS WITH THE NATURAL LOG
TRANSFORMATION

Table 21

Descriptive Statistics for Level-1 Visual Perspective Taking: Processing Costs with Natural Log Transformations

	N	Mean	SD	Minimum	Maximum
Alone					
Other Consistent	40	6.8382	.21753	6.49	7.35
Other Inconsistent	40	7.1353	.37616	6.42	8.34
Self Consistent	40	6.8472	.26486	6.41	7.54
Self Inconsistent	40	6.9468	.36600	6.47	7.94
Dual					
Other Consistent	40	6.8925	.36914	6.31	8.11
Other Inconsistent	40	7.1461	.37489	6.18	8.05
Self Consistent	40	6.9983	.33442	6.46	8.07
Self Inconsistent	40	7.0763	.33737	6.50	8.07

APPENDIX K

DESCRIPTIVE STATISICS FOR LEVEL-1 VISUAL
PERSPECTIVE TAKING TASK: REACTION
TIME BEFORE DATA WERE
WINSORIZED

Table 22

Descriptive Statistics for L-1 VP Task: Reaction Time before Data were Winsorized

	N	Mean	SD	Minimum	Maximum
Alone					
Other Consistent	40	898.20	209.83	587.00	1553.00
Other Inconsistent	40	1111.60	304.35	497.00	2033.00
Self Consistent	40	940.48	267.06	490.00	1882.00
Self Inconsistent	40	978.58	318.79	471.00	1826.00
Dual					
Other Consistent	40	970.35	354.47	548.00	2380.00
Other Inconsistent	40	1094.65	311.15	483.00	2093.00
Self Consistent	40	1064.15	340.47	639.00	2217.00
Self Inconsistent	40	1068.28	253.86	664.00	1637.00

Note. L-1 VP = level-1 visual perspective taking