Social Perception and Neuropsychological Deficits in Mild Cognitive Impairment

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Abstract

Social perception is an important aspect of social communication. Accurate recognition of emotion is crucial to understanding how others are feeling, which in turn is important in developing and maintaining meaningful relationships. Difficulties in social perception may lead to feelings of loneliness and isolation, which affects quality of life and wellbeing. Social support is particularly important, as people get older as it helps foster wellbeing. The process of ageing is related to a gradual and slow decline in cognitive function. This decline is seen to hasten with the onset of dementia. The risk of dementia is greater in people with mild cognitive impairment (MCI). There has been limited research examining social perception in people with MCI and existing research has largely used static visual tasks, such as photographs and stories for assessment of social perception. Further, those studies have predominantly focussed on people with MCI that are more likely to progress to Alzheimer's disease, i.e., amnestic MCI. The present study aimed to assess emotion recognition and complex social perception tasks using an ecologically valid tool - The Awareness of Social Inference Test (TASIT) - in all subtypes of MCI. The overall aims were to examine social perception skills in people with MCI and to examine the relationship between social perception and neuropsychological functioning. Ninety-six healthy participants (females = 69, *M age* = 62.74, *SD* = 8.1) above the age of 50 years were recruited from the community, and 21 participants (females =10, *M age* = 72.24, *SD* = 10.4) with a diagnosis of MCI were recruited from the local District Health Boards (DHBs). These participants were administered a battery of neuropsychological tests (memory, language, executive functioning and visuospatial functioning domains), the TASIT, social activity and network

measures, and informant measures were also collected. Initially, analyses were conducted to determine which of four MCI classification systems (liberal, comprehensive, conventional and conservative) was the most appropriate for use in the current study. This analysis revealed that the conventional criteria (1.5 SD below mean in one measure of a domain) accurately classified all the participants with a diagnosis of MCI, and 49% of the community sample as meeting the criteria for MCI. Overall, 68 participants (58%) met the criteria according to the conventional criteria and 49 participants (42%) were in the non-MCI group.

Analyses revealed no significant differences between the MCI and non-MCI groups on any of the TASIT subtests. In addition, there were no significant differences on TASIT scores between those with multiple domain MCI compared to those with single domain MCI and participants with no MCI. There was no significant association between meeting criteria for MCI and the proportion of participants meeting the cut-off score for moderate deficits on the TASIT. When examining the sub-tests of the TASIT, there was a greater proportion of participants who had deficits on the recognition of emotion (76%) compared to the higher order social perception tests (41%). Finally, all participants obtained significantly higher scores on the recognition of negative emotions, suggesting this was easier than the recognition of positive emotions.

A series of correlations between the TASIT sub-test scores and the neuropsychological domains scores were conducted. The analyses revealed no significant correlations between any of these measures. There were no significant differences between groups on their informant ratings.

Overall, the findings suggest that MCI is not associated with a decline in social perception, as assessed by the TASIT. Furthermore, the results of this study support the suggestion that social perception may be viewed as a separate domain

of functioning, which could be assessed separately as part of a comprehensive neuropsychological assessment. This may assist in the accurate diagnosis of non-amnestic types of MCI, which are more likely to progress to a non-Alzheimer's dementia.

Shuddhimati Ramaseshan

1932-2017

My grandmother was diagnosed with dementia the year I started my research.

This is for you Ammamma.

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Chapter 1-Introduction

Social Perception

There is nothing more routine than communication between people, and we often take for granted the multitude of processes that are involved. A substantial part of effective communication is the ability to identify and predict others' emotions and respond appropriately. Social perception, a term which is often used interchangeably with social cognition, is the ability to pay attention to and interpret a wide range of phenomena of a social nature such as verbal messages, paralinguistic information (e.g., vocal qualities like increased range and amplitude of voice frequency, shorter pauses, etc.), nonverbal behaviours (e.g., facial expressions), and contextual information (e.g., knowledge about potential conflicts between speakers) (McDonald et al., 2006). Social perception shares some aspects with Theory of Mind (ToM), which is the ability to understand other people's mental states including beliefs, emotions, intentions and making predictions about one's own as well as others' behaviour (Premack & Woodruff, 1978).

Social perception is a complex yet automatic process, which is important in the survival of species. For example, being able to recognise fear quickly facilitates appropriate responses to threatening situations (Lewis & Haviland, 1993). Humans are largely social beings. Although social interaction is just as essential for survival in other animals like non-human primates and insectivores like hedgehogs, complex social interaction including the use of sarcasm and humour to convey difficult content, is exclusive to humans.

Studying social perception is not straightforward. For example, the true meaning of certain statements or remarks is essentially a combination of relevant social cues, the speaker's demeanour, knowledge of social conventions in the culture, and the overt content in the form of what has been said. Research in the field of social perception is broadly conducted in two different ways. On one hand, biological or neuroscientific research focuses on the cerebral structures responsible for social perception; on the other hand, neuropsychological studies focus on the performance of people in social perception tests with the aim of detection or rehabilitation of social perceptual issues. Further, depending on the modality of social perception, the assessment tools or stimuli used in assessment are different.

The relatively new field of social neuroscience has been important in advancing research in social perception (Cacioppo & Berntson, 1992). Neuroscientific research is conducted using different approaches. The majority of studies use imaging mechanisms such as fMRI and PET to note the brain's activity while the participant performs an task in order to determine structures and pathways of neural activity that correspond to that task (Bottini et al., 1994; Harada et al., 2009; Mohamed et al., 2006; Samson, Zysset, & Huber, 2008; Uchiyama et al., 2006). Imaging studies are also conducted in people who have neurological, developmental, physical or psychiatric conditions that show specific impairment in social perception and thus deduce the underlying neural mechanisms (Baglio et al., 2012; Kipps, Nestor, Acosta-Cabronero, Arnold, & Hodges, 2009; Malhi et al., 2008; Rankin et al., 2009; Ting, Lee, Marian, & Mirella, 2006). Another useful source of information is through lesion studies; lesion studies can elucidate a causal relationship between a brain structure and an aspect of social perception (Channon et al., 2007; Jaracz, 2010).

Social perception involves various levels of processing (Adolphs, 2003). On a broader level, social interaction begins with basic perception or noticing aspects of the other person–facial changes, voice and body language (Adolphs, 1999a; de Gelder, 2009). This then leads to the recognition of emotions, which is essential to allow higher-order processes including theory of mind and recognising sarcasm or lying. These higher-order levels of social perception also include being able to sustain a conversation which involves multiple facets of conversational inference. For example, someone with good social skills will be able to understand subtle hints expressed in conversation, sarcasm and lies. Studying the biological mechanisms of social perception has enabled us to understand the complex nature of social perception, which begins with the recognition of emotions.

Recognition of emotions

Emotion recognition is paramount for any kind of social communication. One of the first steps in social perception is emotion recognition. It is also useful in higher-order processes of social perception including the recognition of deception, sarcastic comments, irony, humour and empathy (Adolphs, 2003).

Emotions are automatic and shared across cultures. Emotions are divided into basic emotions and complex emotions. Basic emotions are differentiated based on their distinctiveness from other emotions in the way they are expressed, the biology, thoughts, images or memories associated with them, facial expressions, and vocal and antecedent events. The widely accepted universal emotions are anger, fear, surprise, sadness, disgust and happiness (Ekman & Cordaro, 2011). These emotions are present in people shortly after birth and they serve to facilitate survival by communicating needs to other people. Complex

emotions, which include embarrassment, contempt, pride and shame, are also sometimes called social or moral emotions. The development of these emotions depends on the social context and tends to be useful for the broader society as opposed to individual needs. These complex or social/moral emotions are essential, as they assist altruistic behaviours (Trivers, 1971) and punishment (Ernst & Simon, 2002).

Both basic and complex emotions are similar in their appearance as well as function across various cultures (Jablonka, Ginsburg, & Dor, 2012; Tracy & Robins, 2004). The universality of basic emotions has a considerable amount of biological and genetic evidence. For example, congenitally blind people display the same facial expressions as people who can see (Galati, Scherer, & Ricci-Bitti, 1997; Matsumoto & Willingham, 2009). Emotions are depicted by facial expressions, tone of voice and body language. Additional information including context, situational factors and personality factors are also used as cues to accurately recognise emotions.

Emotions play a role in sensitising people to pay attention to their surroundings. In other words, emotions direct attention or act like a "signal function" (Lane, Nadel, & Ahern, 2000). This signal function of emotion implies that we focus our attention towards parts of the environment depending on our current emotional state. For example, the emotion of surprise directs a person's attention to new stimuli that were not expected (Browning & Harmer, 2012; Figueiredo, Chen, & Azevedo, 2015).

The recognition of emotion is automatic (Tracy & Robins, 2008). The reason for its automaticity has some basis in evolutionary theories, making it easier to communicate universally, regardless of people's cultural background (Russell, 1994). There have been several studies of the automaticity of emotion

recognition. Studies of the socio-cognitive development of children provide good evidence that people do not need to use complex and higher-order cognitive functions to recognise emotions. One-year-old children were able to recognise facial emotion and use the information to appraise a situation (Sorce, Emde, Campos, & Klinnert, 1985). They were able to recognise emotions displayed by their mothers as well as differentiate the faces of their mothers from strangers (Minagawa-Kawai et al., 2009).

The automaticity of the recognition of emotion was supported by Tracy and Robins (2008) who examined how the speed at which people recognised complex and basic emotions varied when they were asked to respond as quickly as possible, compared to if they were distracted during the task. The distraction task was included to increase the cognitive load, thereby testing if emotion recognition was an automatic process. People in both conditions were able to identify emotions equally accurately, leading to the conclusion that emotion recognition was independent of conscious cognitive control. Despite using potentially difficult stimuli such as photographs, people were good at recognising all basic emotions and some complex emotions (with the exclusion of contempt) without conscious cognitive effort.

There have been some studies that have found that the recognition of certain emotions was more difficult. For example, Tracy and Robins (2008) found that participants performed poorly at the recognition of contempt. Similarly, Rapcsak et al. (2000) found that healthy participants performed poorly at the recognition of fear in photographs where fear was often confused with surprise. On the other hand, there has been some indication that the automaticity of emotion recognition largely lies in the task difficulty. Tracy and Robins (2008) suggested that the unfamiliarity of the word “contempt” contributed to the poor

performance at its recognition. The inclusion of additional cues such as head tilts (Rosenberg & Ekman, 1995), contextual cues (Ludlow, Garrood, Lawrence, & Gutierrez, 2014) and prosody (Ruffman, Sullivan, & Dittrich, 2009) would make the recognition of emotions easier.

Emotion recognition is shared across cultures and is automatic, however a lack of comprehensive contextual cues can disrupt accurate identification. The recognition of emotions is better when there are more cues present in a test and the more similar it is to real life situations. As well as the different types of tests, emotion recognition deficits may occur when one of the many biological levels of processing are affected. For example, deficits in vision may lead to poor recognition of emotions. The next section explores the biological processes involved in the recognition of emotion.

Biological basis of emotion recognition

The structures of the brain that are involved in processing emotions are also involved in higher social perception skills such as detecting sarcasm. Briefly, there are three levels of processing involved in the recognition of emotion. At first, the information from the external stimuli is communicated through sensory organs such as the ears and eyes and transmitted to the sensory regions of the brain (Barbas, Zikopoulos, & Timbie, 2011). The next level of processing takes place at the amygdala, ventral striatum and the orbitofrontal cortex (Gosselin et al., 2005; Winston, O'Doherty, & Dolan, 2003). The amygdala and the orbitofrontal cortex serve slightly different functions. The amygdala is involved in encoding stimuli, while the orbitofrontal cortex is responsible for use of the information to decipher its reward value by taking into consideration context and

experience (Barrett, Mesquita, Ochsner, & Gross, 2007; Day & Walker, 2012; Rudebeck, Bannerman, & Rushworth, 2008).

This first level of processing occurs consciously or unconsciously (Ledoux, 2012). An unconscious appraisal of emotion occurs in the face of a dangerous situation that is either a species typical response or a previously learned one. An example of a species typical behaviour is the fear of heights, which is processed unconsciously by the amygdala (Steimer, 2002). An example of a previously learned situation is where victims of sexual trauma detect perceived danger cues in the environment unconsciously, leading to a response (Diamond & Zoladz, 2016; Rocha-Rego et al., 2012). These main brain regions process the information and trigger associative knowledge from other areas, such as the hippocampus, in recognising the emotional response, processing this cognitively and deciding what the next course of action needs to be (Adolphs, 2002). In other words, these brain areas aid emotion appraisal.

The third level of processing involves the left prefrontal cortex, right parietal and anterior and posterior cingulate cortices. These brain regions are involved in more complex processes such as considering the context of a situation, deciding whether an action may affect the wider social group, and deciding how to react based on how others may perceive the response (Adolphs, 2003).

At a basic level, the three processes depend on each other, and the interactions that occur are complex. The first level of processing occurs in all animals and is automatic (Barbas et al., 2011). However, human beings need higher-level processes, as they aid difficult aspects of social perception such as perceiving sarcasm and lies, and being empathetic.

The sensory level of processing is when recognition of emotions starts from auditory or visual channels, as described above. The recognition of emotions through tactile and olfactory senses is far less important in humans as compared with other animals (Adolphs, 2003). Much visual recognition of emotion takes place by paying attention to the face and body gestures. There are different regions in the brain that collate this information and enable human beings to recognise facial expressions. The fusiform gyrus is responsible for processing the structural and stationary properties of faces and helps in recognising faces (Elizabeth & James, 2000; Haxby, Hoffman, & Gobbini, 2000; Vuilleumier & Pourtois, 2007). The temporal lobe, specifically the anterior and dorsal regions, are engaged when perceiving facial expressions and movements in the eyes and the mouth (Elizabeth & James, 2000; Haxby et al., 2000). The dorsal and ventral visual streams in the brain are responsible for shape and motion information that contributes to recognition of emotion (Lucia, Jeffrey, Sanjida, Pawan, & John, 2001).

Auditory input gives us important information about prosody, frequency and amplitude of voice. Prosody is "the rhythmic and intonational aspect of language" (Ince, 2013). However, the recognition of basic emotions through only visual means has been shown to be easier than if only prosodic information was available. For example, emotions like disgust are difficult to recognise only through prosodic information (Scherer, Banse, Wallbott, & Goldbeck, 1991). The recognition of emotion via auditory means has been found to involve many of the same brain structures as emotion recognition via visual processing, except that the perceptual information from auditory stimuli follows the auditory streams (Adolphs, 2002). In conclusion, the recognition of emotions involves multiple

regions of the brain and is mostly automatic. Basic emotion recognition has a well-understood neural basis.

There is evidence for specific brain structures being associated with the recognition of specific basic emotions. In some studies, the amygdala has been associated with the recognition of the emotion in all the basic emotions–happiness (Kipps, Duggins, McCusker, & Calder, 2007), fear (Sophie et al., 1997), disgust (Kipps et al., 2007), surprise (Zhao, Zhao, Zhang, Cui, & Fu, 2017), sadness (Blair, Morris, Frith, Perrett, & Dolan, 1999) and anger (Sophie et al., 1997). Further, the recognition of all the emotions via facial information (as opposed to voice) may take place in the fusiform cortex (Vuilleumier & Pourtois, 2007). Studies with people who have amygdala damage show deficits in the recognition of fear from facial photographs (Becker et al., 2012; Broks et al., 1998; de La Tremblaye & Plamondon, 2011). The recognition of sadness may also take place in the left amygdala and the temporal pole (Blair et al., 1999). Enhanced activity in the orbitofrontal and anterior cingulate cortex was seen on imagining scans when participants recognised angry faces (Blair et al., 1999). Further, the recognition of anger was impaired in people who had bilateral amygdala lesions (Sophie et al., 1997). The anterior cingulate, posterior cingulate, medial frontal cortex (Phillips et al., 1998), fusiform gyrus, calcarine sulcus and the right superior temporal gyrus (Morris et al., 1998) have seen to be been associated with the recognition of happiness. The insula, also known as the gustatory cortex may also be involved when recognising disgust (Phillips et al., 1997). This structure has been specifically related with disgust, with the knowledge that the emotion of disgust is frequently associated with contamination by an unpleasant stimulus and thus linked to gustation or taste (Rozin & Fallon, 1987). The recognition of surprise may be associated with parahippocampal gyrus, fusiform gyrus and the

amygdala (Zhao et al., 2017). However, the brain functions as a complex neural circuit. Attributing a single brain function or a structure to the recognition of emotion may be an oversimplification (Ruffman, Henry, Livingstone, & Phillips, 2008b; Vuilleumier & Pourtois, 2007).

The recognition of emotions involves complex interactions across different parts of the brain. Fortunately, this ability is not associated with complex cognitive faculties, and this makes accurate emotion recognition possible for most people. This automaticity is important in the survival of our species by aiding in quick and often necessary responses to the dangers in the environment. Recognition of emotion is crucial to interpersonal interactions, and underpins more complex functions such as understanding context, forming associations with what has been spoken and information about the speaker's characteristics. This emotion recognition aids complex social interactions: for instance, understanding the intent of what has been spoken, deciphering sarcasm and knowing what the other person might be thinking.

Higher-order social perception

Social perception is broad and multifaceted. Once able to recognise another person's emotion, we are then able to make predictions about their mental state and their behaviour. These high order processes have been defined using many terms–theory of mind (ToM), mentalising, metacognition, to name a few. ToM is the ability to attribute mental states to other people and be able to interpret, explain and predict their behaviour (Premack & Woodruff, 1978). ToM helps with decoding subtle social cues in order to understand the mental states of ourselves and others (Martín-Rodríguez & León-Carrión, 2010). ToM is needed in everyday life, as it is required in social skills such as empathy, compassion, and recognition

of sarcasm and deceit. Many studies have used the recognition of sarcasm, lies and deceit as a means to examine ToM. Assessments such as the false belief tasks, and empathy tasks that capture the recognition of counterfactual information can be an important source of information about ToM abilities.

Higher-order social perception is called so because it requires more cognitive effort. There are a few steps that lead to higher social perception recognition (Adolphs, 2003). In order to judge what another person is thinking, the first step is to perceive all the information available–facial expression, prosody, context, personality characteristics of the person (if available). The next step is to briefly abandon one's own thoughts and emotions and assume what the other person's thoughts and emotions may be. This assumption is also served by being able to use one's own mind as a "model" to be able to assume what the other person is likely to be feeling. Failure to correctly infer what the other person is thinking or feeling may be due to impairment at any of the levels as described above (the three levels of processing). For example, if a person does not receive enough information, this may lead to a misinterpretation of the situation. Therefore, people with certain disabilities find it difficult to recognise theory of mind functions like recognising sarcasm in others. For example, one of the hallmark symptoms of people with autism is difficulty with ToM.

Higher order social perception ability may not always be related to the recognition of emotions. McDonald and Flanagan (2004) examined the interaction between emotion recognition and social perception abilities using the TASIT with people with traumatic brain injury. They found that while there were some participants who had difficulties in recognising emotions, they did not have difficulties in recognising conversational inference in the form of recognising sarcasm and lying. Emotion recognition and first-order theory of mind judgements

were not related to the ability to understand social inference, while second order theory of mind judgements were related to that ability. This suggests that social perception relies on a variety of different abilities

Although complex in theory, some studies have found ToM is largely independent of cognitive functions. A narrative review of 30 studies of ToM and neuropsychological functions in schizophrenia patients was carried out by Harrington, Siegert, and McClure (2005). Twenty-six out of the 30 studies found that accurate recognition of ToM was independent of neuropsychological functions like memory, executive functioning and general intellectual ability. Further, in comparing children who have high functioning autism with healthy controls and children who have Down's Syndrome (with a mental age of at least 4) in their recognition of ToM, similar results have been found (Baron-Cohen, Leslie, & Frith, 1985). On average, the autistic children had a much higher IQ (82) than the Down's syndrome children (64). The IQ included both verbal and nonverbal scales. The autistic children performed poorly compared to the normal and the Down's syndrome children. The Sally-Anne task (Simon Baron-Cohen, Alan M. Leslie, & Uta Frith, 1985) was used as the ToM measure. This is a change-of-location task to assess ToM in children. In this task, Sally places a marble in a box and leaves the room. During this time, Anne moves the marble from the box and places it in a basket. The participant is asked the question "When Sally comes back, where will she look for her marble?"

In contrast, other studies report that ToM is associated with higher order cognitive functions. Experimental studies that used neuropsychological tests have looked into the relationship between the aspects of ToM and cognitive functions such as language, memory and executive functioning. In one such study, McDonald et al. (2014) assessed people with traumatic brain injuries (TBIs) to examine the

relationship between ToM and executive dysfunctions commonly seen in people with TBIs. The authors used TASIT (McDonald, Flanagan, Rollins, & Kinch, 2003a), Reading the Mind in the Eyes Test (RMET)–Revised (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001) and the Perspective Taking (PT) subscale from the Interpersonal Reactivity Index (IRI) (Davis, 1980) to assess social cognition, ToM, and cognitive empathy, respectively. This experiment was divided into low executive function load condition, high flexibility load condition and high inhibition load condition. Each of these conditions were divided into low ToM and high ToM. Specifically, in the low executive function load and low ToM condition, the participant was asked to describe the features of the holiday resort in a picture. In the high ToM task in the same condition participants had to describe the advantages of the resort for a couple with children. This was included in order to look into the varying amounts of executive demands on ToM. The authors found that poor ToM performance was related to poor executive functioning.

The complexity of higher-order social perception is understood through developmental theories. Recursive thinking, the ability to think about thinking, is thought to be the basis of theory of mind (Corballis, 2011). First-order recursive thinking (i.e., “I think that you think”) has been observed in children as early as 4 years of age (Wimmer & Perner, 1983). Second-order recursive thinking ("I think that you think that she/he thinks") appears in 8-year-olds (Perner & Wimmer, 1985), but it is only in adolescence and early adulthood that third-order beliefs (“I think that you think that he/she thinks that another person thinks…”) develop (Valle, Massaro, Castelli, & Marchetti, 2015). Adolescents start to show an increasing interest in the social environment outside the immediate family, and this opens a completely new world of social independence. It is realistic to think that ToM skills would develop at this stage, adapting to the new social needs. By

age 13, adolescents are able to assess emotional situations from a first and a third person perspective at a faster rate (Keulers, Stiers, Jolles, & Evers, 2010). They are quite accurate at recognising emotions, sarcasm, and lies, but still not as good at it as adults are (McDonald et al., 2015).

Higher-order social perception serves many functions. In fact, from an evolutionary standpoint, these complex processes are essential for the survival of the species of humans. Humans are social beings, and the success of the human civilisation is evidenced by the formation of complex social interactions from a micro level (family) to a macro level (society, cultures, etc.). Being able to infer another person's state of mind guides how we plan our own actions. An example is being aware of potential behaviours of other drivers when driving on the road. Further, higher social perception processes help with forming bonds with other people by being able to "read" what another person is feeling and thus sharing that feeling. This is more commonly known as empathy, which results in compassion.

An important higher-order social perception process is the ability to process information that is delivered in a counterfactual manner, such as when someone has spoken a lie or has passed a sarcastic remark. This involves careful reflection on cues that are beyond what has been spoken. These complex processes are also dependent on the recognition of emotions as well as the development of empathy or ToM (Andrew, Juanita, & Penny, 2013). This is evidence to suggest that using sarcasm is indeed a complex task.

Recognition of sarcasm

Sarcasm is an indirect form of speech where an implied criticism of something is conveyed through contextual and paralinguistic cues such as vocal qualities and rolling of eyes (McDonald, 1999). Sarcasm is a form of irony, which is a broader

term to convey messages in an indirect manner. There are a few functions of sarcasm. It is used to increase the level of perceived politeness in the speaker (Jorgensen, 1996). This has been based on Brown and Levinson (1987) politeness theory, which posits that indirectness in speech is perceived by the listener as being polite. Another function of sarcasm is to decrease the potential aggressiveness of a critical remark (Dews & Winner, 1995).

The TASIT which is developed by McDonald (2012) differentiates between two kinds of sarcasm–simple and paradoxical. Simple sarcasm is recognised when a neutral statement is spoken with exaggeration of vocal, facial and body language. For example, the statement "I have got plenty of time" is interpreted as sarcasm if the speaker enhanced the tone of voice, rolled their eyes and emphasised the word "plenty." On the other hand, paradoxical sarcasm is when the statement does not make any sense unless interpreted as sarcasm.

Verbal communication does not solely rely on face-to-face conversations. Complex social perception processes such as sarcasm can be communicated through a simple statement that may be counterfactual. An example of a counterfactual statement is criticism conveyed in an overly positive manner ("Great! What a terrific start to this party!"). Sarcasm can also be communicated through an echoic statement (Srinivasan & Massaro, 2003), which is a statement that is posed as a question ("Ashlyn ate the entire bar of chocolate?") or an understatement ("That was just a minor oil spill") (Gibbs, 2000). These statements make it possible for sarcasm to be communicated through text. Alternatively, face-to-face interpretations of sarcasm rely heavily on the paralinguistic cues (such as vocal qualities, including but not limited to an increased range and amplitude of voice frequencies, smaller pauses, higher empathic stress and an exaggerated lengthening of syllables) that alert the listener to go beyond the actual

content of the speech, which may be perceived as sincere if it were not for these cues (Anolli, Ciceri, & Infantino, 2000; Rockwell, 2007). Some other paralinguistic cues of sarcasm include facial cues like widening of eyes, rolling of eyes, increased and rapid blinking, grimacing and smirks (Anolli et al., 2000; Rockwell, 2007). Prosody serves as an important cue in the recognition of sarcasm. Four different types of prosody contribute to language (Monrad-Krohn, 1947). Emotional prosody differentiates between various types of emotions. Linguistic prosody differentiates between questions and statements. Inarticulate prosody includes aspects of non-speech sounds like moans and sighs and attitudinal prosody provides cues regarding the person's attitudes like enthusiasm, doubt, and faith. Sarcasm uses attitudinal prosody (Boss, 1996). A positive or a neutral statement that is spoken in a negative tone will direct the attention of the listener to conclude that the person is being sarcastic. In addition to prosody, amplitude, loudness, and a reduction in pauses can also provide important cues in recognising sarcasm (Gelinas-Chebat & Chebat, 1992). In addition to the role of physical emotional cues, sarcasm can also be conveyed by text. This is evidenced in the assessment of recognition of sarcasm. Most studies in the recognition of sarcasm have used text-based stories that contain sarcastic comments (Adachi et al., 2004; Maki et al., 2013). For example, the Metaphor and Sarcasm Scenario Test (MSST) is a tool that consists of five metaphoric and sarcastic scenarios in the form of words and sentences (Maki et al., 2013).

Recognising sarcasm is a complex task. Children as young as six years are able to accurately understand sarcasm and irony (Ackerman, 1983; Glenwright & Pexman, 2010; Hancock, Dunham, & Purdy, 2000; Harris & Pexman, 2003). However, appreciation of sarcasm and irony develops in two steps. At four or five, children can understand what the sarcastic speaker believes (first-order

attributions); it is not until between six and eight that children grasp the intent of a sarcastic statement (second-order attributions) (Glenwright & Pexman, 2010; Sullivan, Winner, & Hopfield, 1995). Six-year-old children were also able to make sense of a speaker's personality characteristics based on their interpretations of the speaker's ironic remarks (Pexman, Glenwright, Hala, Kowbel, & Jungen, 2006).

A complete understanding of sarcasm only occurs in middle childhood. In a review of papers relating to the development of sarcasm, Creusere (1999) found that young children around age six misinterpreted sarcasm as deception. However, as they grew older, between ages nine to 13, the differentiation between deception and sarcasm was more prominent, and they were able to make accurate judgements about a person being sarcastic (Demorest, Meyer, Phelps, Gardner, & Winner, 1984). Children as young as eight rely on intonation to recognise sarcasm, and as they grow older, they use contextual information as well as intonation to recognise sarcasm in conversations (Capelli, Nakagawa, & Madden, 1990).

The recognition of sarcasm is complex, and difficulties in this skill can happen at various levels. Based on the developmental studies mentioned above, it is not surprising that people with certain neurological disorders have difficulties in recognising sarcasm. There have been numerous studies that have found deficits in recognition of sarcasm through contextual cues in people with schizophrenia (Cassetta & Goghari, 2014; Kantrowitz, Hoptman, Leitman, Silipo, & Javitt, 2014; Mitchell & Rossell, 2014), autism (Channon, Crawford, Orlowska, Parikh, & Thoma, 2013; Persicke, Tarbox, Ranick, & St. Clair, 2012), dementia (Bora, Walterfang, & Velakoulis, 2015; Kipps et al., 2009; Moos, 2011; Rapp & Wild, 2011), epilepsy (Raud, Kaldoja, & Kolk, 2015; Stewart, Catroppa, & Lah, 2016)

and traumatic brain injury (Johnson, Crane, & Tatekawa, 2004; McDonald et al., 2013).

The assessment of social perception in general has until recently focussed on contrived stimuli that are devoid of contextual information, in the form of audiotaped exchanges and written scripts such as stories. These forms of assessment make the task extremely difficult and add cognitive load over and above what is required to infer these complex forms of social interactions. While research has focussed on the ability to recognise higher order social perception, such as ToM, empathy and irony, and the recognition of sarcasm, it has not always been assessed using psychometrically robust tests.

Currently there is only one structured and standardised assessment tool for the recognition of sarcasm. This test is called the Awareness of Social Inference Test (TASIT), which uses prosody, emotion expressions, and context as cues, making it as close to a real-life situation as possible. The TASIT uses video vignettes that depict different actors who are being sarcastic, lying, or being sincere in scenes depicted in a series of videos 15-30 seconds long (McDonald, Flanagan, Rollins, & Kinch, 2003b). The videos of simple sarcasm relied on identifying nonverbal cues to recognise intent, whilst, paradoxical sarcasm is more dependent on the semantics of the statement. At the end of each video, the participant is asked to answer four questions relating to what a person is doing to the other person, what they are trying to say, what they are thinking (which may be different from what they are saying) and how they are feeling.

Biological basis of the recognition of sarcasm.

Like the recognition of emotions, the recognition of sarcasm also requires multiple levels of processing. Although the perception of facial expressions is an

important aspect (Williams, Burns, & Harmon, 2009), emotional detection in sarcasm is best processed through acoustic information (Rockwell, 2007). Visual cues that help recognition of sarcasm are changes in the range and intensity of facial expression displayed by the communicator, rolling eyes, widening eyes, increased eye blinks, and smirks (Rockwell, 2001). Acoustic cues include information such as pitch, tone, intensity, pauses, and volume (Anolli et al., 2000; Bryant & Fox Tree, 2005; Cheang & Pell, 2008; Glenwright, Parackel, Cheung, & Nilsen, 2014; Woodland & Voyer, 2011). Lay people may term this as having a "sarcastic tone."

Sarcasm is frequently associated with negative affect (Sperber & Wilson, 1986) such as disapproval, contempt and disdain and negative emotions are processed differently. Parts of the left orbitofrontal cortex are activated by negative emotions, including when a person perceives an angry expression (Pascal et al., 2013; Willis, Palermo, McGrillen, & Miller, 2014), or if they themselves are made to feel angry (Dougherty et al., 1999). The orbitofrontal cortex is also involved in sarcastic exchanges, possibly because they are likely to make the other person feel angry (Berthoz, Armony, Blair, & Dolan, 2002). The temporal lobe has been recognised as the region where the sensory modalities unite (Moran, Mufson, & Mesulam, 1987), therefore receiving the sensory input of information– in this case sarcasm.

Once the initial levels of sensory processing are complete, the understanding of sarcasm requires complex processes including language, memory and executive functioning. To recognise if a person is being sarcastic, the person first has to understand the sentence spoken, which relies on knowledge about the language. Memory functions are related to the recognition of sarcasm. One of its functions is the formation of scripts, which provides emotional and semantic context based on

past experiences. Information regarding contextual cues are stored in memory. These contextual cues help in the recognition of sarcasm (Shany-Ur et al., 2012). Although complex, the detection of sarcasm occurs quickly. Executive functions including attention and speed of processing are involved in the recognition of sarcasm.

The regions of the brain involved in the detection of sarcasm, once primary processing is complete, are complex. It activates the same circuits of the brain as those responsible for language and executive functioning tasks, including the temporal and the frontal lobes suggesting that the processes are related (Uchiyama et al., 2006).

The temporal pole and the medial prefrontal cortex (MPFC) are involved in aspects of recognition of sarcasm as well as cognitive processes. Studies with people with neurological insult to the temporal lobe (e.g., temporal lobe epilepsy and frontotemporal dementia) often suffer from ToM deficits (Cohn, St-Laurent, Barnett, & McAndrews, 2015; Hennion et al., 2015), which could contribute to difficulties in recognition of sarcasm. In addition, the temporal lobe, specifically the left temporal lobe, is involved in the memory retrieval of scripts (Maguire, Frith, & Morris, 1999; Westerlund & Pylkkänen, 2014). The temporal pole is responsible for the nuances of language: for instance, the construction of a sentence (Vandenberghe, Nobre, & Price, 2002), and other specific semantics (Bottini et al., 1994) including non-literal language (Bohrn, Altmann, & Jacobs, 2012). Imaging studies, which assess the recognition of sarcasm through stories or textual cues, have shown activity in the temporal pole (Arzouan, Goldstein, & Faust, 2007; Champagne, Virbel, Nespoulous, & Joanette, 2003; Eviatar & Just, 2006).

The MPFC is an important part of the brain that receives information from the temporal lobe (Bachevalier, Meunier, Lu, & Ungerleider, 1997) and is responsible for the non-automatic and conscious aspects of the detection of sarcasm (Ferstl & Cramon, 2002). The MPFC functions by generating hypotheses based on the knowledge derived from past experiences. It is responsible for tasks such as making judgements based on information generated through language (Ferstl & Cramon, 2002; Otsuka, Osaka, Yaoi, & Osaka, 2011), making evaluative judgements based on societal norms and values (Hervé, Razafimandimby, Jobard, & Tzourio-Mazoyer, 2013; Zysset, Huber, Ferstl, & Von Cramon, 2002), self-referential mental activity (Debra, Erbil, Gordon, & Marcus, 2001; Kim, 2012), and moral judgement (D'Argembeau et al., 2005; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Yoder & Decety, 2014). Although these are the main structures of the brain associated with the recognition of sarcasm, other brain structures are also involved, including the corpus collosum.

The major function of the corpus callosum is communication between the two hemispheres, and both the right and the left hemispheres are involved in the recognition of sarcasm. Not surprisingly, people with complete agenesis or lack of the corpus callosum, along with other cognitive issues, have difficulties in aspects of social cognition, including recognition of emotions, sarcasm detection and ToM tasks (Symington, Paul, Symington, Ono, & Brown, 2010). Symington et al. (2010) compared 11 high functioning participants with complete agenesis of the corpus callosum to 13 matched controls on tasks of social cognition. The authors found that their clinical sample performed poorly on the recognition of emotion and recognition of paradoxical sarcasm. They also found that the participants with agenesis of the corpus callosum struggled more with textual or language cues as

compared to the visual cues, implying that the corpus callosum is an important feature that helps in the understanding of second-order language. This has been demonstrated in numerous other studies also (Brown, Paul, Symington, & Dietrich, 2005; Gavrilescu et al., 2010). Other studies have found evidence to suggest that the corpus callosum is involved in the comprehension of second-order meanings (Paul, Van Lancker-Sidtis, Schieffer, Dietrich, & Brown, 2003), nonliteral items (Brown, Symingtion, VanLancker-Sidtis, Dietrich, & Paul, 2005) and narrative humour (Brown et al., 2005). Therefore, these functions appear to involve both hemispheres of the brain. The findings about the relationship between various cognitive functions and the recognition of sarcasm is seen in a few neuropsychological studies and this is not consistent

The cognitive correlates of sarcasm comprehension are confirmed in people with dementia who had deficits in the recognition of sarcasm tasks in the TASIT. Rankin et al. (2009) identified 15 out of 90 (17%) people with dementia who had deficits in the recognition of sarcasm on the TASIT. Recognition of sarcasm was positively related to language and verbal memory. However, inhibition, working memory, and visuospatial functioning were not related to the recognition of sarcasm. Another important study conducted to examine the cognitive correlates of social perception, including the recognition of sarcasm, was by McDonald et al. (2006). By assessing participants who had a brain injury, they concluded that various cognitive abilities such as face perception, information processing speed, executive functioning, working memory, learning new material and conceptual reasoning were associated with social perception as assessed by the TASIT.

Spikman, Timmerman, Milders, Veenstra, and van Der Naalt (2012) conducted a study of social cognition with TBI patients. Tests of social cognition were conducted, including emotion recognition assessed by Facial Expressions of

Emotion-Stimuli and Tests (FEEST) (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002), ToM was assessed using the Cartoon Test (Happé, Brownell, & Winner, 1999) and the short version Faux Pas test (Stone, Baron-Cohen, & Knight, 1998). The neuropsychological measures assessed memory mental speed, attention and executive function. There were no significant relationships between neuropsychological and social perception domains; however, the authors note that their assessment of executive functioning focused on planning, and future studies could include tests of inhibitory control and flexibility.

Another important aspect that requires complex social perception skills and ToM is the recognition of lying.

Recognition of lying

Lying has been defined as "intentionally (trying) to mislead someone" (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996, p. 991). Almost 81% of people admitted to lying at least once during a study interview and 34% of people have admitted to having lied to their spouses at some point during their relationship (DePaulo & Kashy, 1998), making lying quite common. Lying serves several functions. Some lies are told with the goal of making the other person feel better (altruistic lies). These lies could be compliments, pretending to agree with the other person or understand them. This in turn could serve to display care and support and to foster a positive bond between people. Other lies may be more self-serving and benefit the person telling the lie (DePaulo & Kashy, 1998). These lies serve the purpose of making oneself feel better, to achieve some sort of material gain (e.g., securing a job), protect oneself from hurt or embarrassment, gain affection, or increase self-esteem. During interactions with other people, determining whether they were telling the truth has an important evolutionary

function as well. Failure to determine that a person has lied may lead to an inaccurate appraisal of the person's honesty, which may be a disadvantage to the person who is being lied to.

The recognition of lying is a difficult task and requires many cues to be able to make a judgement. Because of this, when judging if a person has been lying, people achieve only slightly above chance level of accuracy (DePaulo et al., 1996; Hartwig & Bond Jr, 2011; Vrij, 2008). Two explanations have been proposed to explain the reasons for inaccurate recognition of lying. One of the explanations is "wrong subjective cue hypothesis," which states that people are poor at recognising the characteristics of lying. Numerous self-report studies have shown that people report lying to be characterised by high vocal pitch, slow speech (Zuckerman & Rosenthal, 1981), hesitancy, fidgetiness, other signs of nervousness like speech errors, more pauses, avoidance of eye contact (Malone, 2001), as well as excessive amounts of eye contact (Vrij, 2008). However, research has found a low correlation between lie detection and eye contact, fidgeting or gaze aversion (Hartwig & Bond Jr, 2011; Vrij, 2008).

The other explanation for inaccuracies in the recognition of lying is the "weak objective cue hypothesis," which states that there are no particular behavioural aspects that accompany lying. In other words, people who lie try their best to seem sincere and therefore do not look any different from a truth teller. DePaulo et al. (2003) conducted a meta-analysis of 116 papers on deception, where the behaviour while lying was compared with the behaviour while people told the truth. From these papers, they identified 158 different cues to deception that were further divided into five different categories. These were how forthcoming liars were (e.g., response length, cognitive complexity, rate of speaking), how compelling the lies were (e.g., plausibility, facial expressiveness),

how positive the liars were (ex. friendly, pleasantness, smiling), how tense liars were (ex. frequency, pitch of vice, blinking, fidgeting), and the amount of ordinary imperfections and unusual content (self-doubt, spontaneous corrections). The authors found that in laboratory experiments using mediums that were clearly meant to contain material that were lies and providing the participant with contextual information, it was easier to recognise a lie. However, the recognition of lies in everyday life was clearly quite difficult, as people lying in real life often behaved similarly to truth tellers.

The detection of lying behaviour follows a developmental sequence, reinforcing the theory that this is indeed a complex social perception skill. As we know, young children are able to recognise emotions. The process of ToM is involved when judging if a person was lying (Harada et al., 2009). As explained in the previous section, ToM also develops in young children between the ages of five and nine. When discussing the recognition of lying, younger children are unable to use information about the discrepancy between verbal and non-verbal behaviour to detect lying (Talwar, Crossman, Gulmi, Renaud, & Williams, 2009). School-aged children are better able to make judgements about truth telling, possibly because lying is an interpersonal and socio-cultural learning that develops through experience. Children as young as three are able to understand the concept of lying. The moral implications of lying become clearer when they are in their preschool years. By the age of six, children are able to understand intent in the person lying (Lee, 2000).

Most of the research on the recognition of lying has been in laboratory based studies involving college students who were asked to deliver truthful or false statements. It is only recently that the standardised assessment of lying has been given attention. Most of the assessment of lying in research has focussed on

using stories or stimuli that have not been standardised. The recognition of lying in everyday communication has been researched in two different ways. Research has focussed on the lie-telling behaviour (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009; Ganis, Kosslyn, Stose, & Thompson, 2003; Mohamed et al., 2006) and the detection of lying (DePaulo & Kashy, 1998). Research with the lie recipient or the recognition of lying in everyday conversation typically used video vignettes as assessment tools that were not normed or standardised. In the research that has used standardised tools of assessing lying, they have found that people do not tend to make mistakes in the detection of lying (Kern et al., 2009) which is different from real life scenarios where they do make mistakes.

The TASIT is currently the only standardised instrument that measures the detection of lying and consists of contextual information that make it easy to detect lies. The true state of affairs is revealed in the beginning of the video followed by the lie being told. For example, in one video, Ruth is seen telling her colleague that Keith smashed the boss's car and that the boss would not understand. When Keith walks in and expresses worry about the boss firing him, Ruth lies to him saying that the boss would understand. The vignettes consist of people largely telling white lies. Kern et al. (2009) found that schizophrenic participants performed better in the recognition of lying as compared to the recognition of sarcasm on the TASIT. They pointed to the fact that while one needed to pay attention to the video and the information delivered, additional demands on information processing was not present in the lying condition. On the other hand, people with multiple sclerosis (MS) performed poorly on the recognition of lying on the TASIT compared to healthy controls (Genova, Cagna, Chiaravalloti, Deluca, & Lengenfelder, 2016). One of the variables that explain these differences is the level of cognitive deficits present in both of these

populations. While the study with MS patients included various neuropsychological measures which showed impairment, the one with schizophrenics did not assess the participants' cognitive abilities.

This suggests that there may be a link between higher-order cognition and the recognition of lying and leads to the question of what parts of the brain are responsible for lie recognition.

Biological basis of recognition of lying

In determining the various cognitive and neurological aspects of the recognition of lying, imaging as well as neuropsychological studies have been carried out. These have largely used unstandardised video stimuli and more recently the TASIT, the only known standardised tool that assesses the recognition of lying. The imaging studies used to examine lying are similar to the ones discussed in the biological basis of emotion recognition and the recognition of sarcasm (see page number 6 and 17) and include studies using fMRI (Ganis et al., 2003; Lee, Lee, Raine, & Chan, 2010), PET (Abe et al., 2006), as well as transcranial direct current stimulation (tDCS) (Karim et al., 2010).

The neural correlates of lying point to the involvement of different parts of the brain depending on the recognition of an antisocial lie and a lie for prosocial causes. An imaging study conducted by Harada et al. (2009), prepared 28 stories depicting a protagonist who was either performing a good deed or one that deviated from social norms. Participants were asked to indicate if the protagonist was morally bad or good, and if they were lying or telling the truth. The temporal pole was engaged in the recognition of lies and the moral task (similar to that of the recognition of sarcasm). The temporal pole, as mentioned earlier, is the region that receives sensory input, as well as information from the limbic system (Moran

et al., 1987). The left temporal pole has already been established as an important part of the brain that is associated with language processes (Bottini et al., 1994) as well as memory retrieval (Fink et al., 1996). However Harada et al. (2009) found that the left temporo-parietal junction (TPJ) was activated largely when the lies were said for anti-social purposes as opposed to prosocial reasons. The role of the TPJ in the recognition of lying has been found by other studies as well (Harada et al., 2009; Young & Saxe, 2008).

In another fMRI study of the neural correlates of the recognition of lying, Wu, Loke, Xu, and Lee (2011) showed 20 participants lying stories and truth-telling stories. The lying stories were further divided into *bad-act lying* (antisocial lies) and *good-act lying* (prosocial lies). The truth-telling stories were further divided into *bad-act truth telling* (telling the truth after a wrongdoing) and a *good-act truth telling* (telling the truth after a good act). The areas involved in antisocial lies were right lingual gyrus (LG), the post central gyrus (PoCG), the right precuneus, the bilateral inferior parietal lobule (IPL) and the TPJ. The areas of the brain involved in processing negatively valenced information are the LG and the PoCG (Isenberg et al., 1999; Ruby & Decety, 2004). The recognition of lying does entail ToM processes, and this is further displayed in the parts of the brain that are activated when recognising lying which are also involved in making ToM judgements. These are the TPJ (Saxe & Kanwisher, 2003; Xiaoqin et al., 2016), the LG (Gobbini, Koralek, Bryan, Montgomery, & Haxby, 2007; Völlm et al., 2006), the PoCG (Fiddick, Spampinato, & Grafman, 2005), the IPL (Gobbini et al., 2007), and the precuneus (Young & Saxe, 2008). In addition to the specific brain regions closely related to the act of deciphering if a person has lied, other regions that are primarily involved in higher-order cognitive processes such as language are also involved. The prefrontal cortex, which is involved in linguistic

coherence and comprehension of spoken language, is one such region (Ferstl & von Cramon, 2002).

In addition to imaging research, studies have been conducted using neuropsychological measures in order to determine the relationship between cognitive processes and the recognition of lying. All studies to date found a relationship between cognitive performance and recognition of lying. One such study was by Genova et al. (2016). Fifteen participants with MS and 15 healthy controls were assessed using the TASIT and a range of neuropsychological measures including premorbid IQ. The people with MS were worse at recognising lies, and this correlated with their performance in memory, learning, processing speed and working memory. Further, premorbid IQ was positively related to the recognition of lies. It is of note that none of the participants with MS had impairments on the neuropsychological tests with the exception of processing speed.

Similarly, Shany-Ur et al. (2012) found a significant relationship between global cognitive functioning and the recognition of lying, using the TASIT in a sample of people with dementia. They assessed 102 people with four different types of dementia and 77 healthy controls. They assessed recognition of lying using the TASIT and neuropsychological tests assessing general mental status, memory, language, visuospatial functioning and executive functioning. The people with deficits in the recognition of lying were identified if they performed 1.5 SD below the mean. People with behaviour variant frontotemporal dementia (bvFTD) performed poorly compared to other types of dementia, and they also had higher functional impairment. People with other neurological conditions such as progressive supranuclear palsy (PSP) also had deficits in the recognition of

lying, which was related mostly to their cognitive impairment rather than a deficit in ToM.

Once again, just like with the recognition of sarcasm, although specific regions of the brain and intact cognitive function help with the recognition of lying, the interaction is complex. Even with the recent development of standardised tools to assess complex ToM functions, the research in the area of social perception and its relationship with neuropsychological functions is still in its infancy. Further, most research focusses on either young college participants or those with moderate to severe forms of disorders.

Social perception in older people

Social perception, like other human functions, follows a developmental pattern. Not surprisingly, the recognition of emotion is the first to develop. Infants are able to recognise emotions through the tone of voice (Heck, Chroust, White, Jubran, & Bhatt, 2018; Minagawa-Kawai et al., 2009) and facial expressions (Minagawa-Kawai et al., 2009; Sorce et al., 1985). As children grow, they are able to recognise referential intent, using a speaker's gaze, speaker's self-correction, and other factors which they use as cues to understand meanings of newly heard words (Lewis & Mitchell, 2014). Children as young as 6 years are able to accurately understand sarcasm and irony (Ackerman, 1983; Glenwright & Pexman, 2010; Hancock et al., 2000; Harris & Pexman, 2003). As described previously, the higher-order functions show strong relationships with neural and cognitive changes. Therefore, we might expect that deterioration in brain function due to ageing would affect people's ability to process these higher-order elements of social perception.

Social perception in the process of ageing is not well studied. In order to understand any changes in social perception with ageing, it is important to also understand the other changes that occur because of the ageing process. These include changes in the physical realm–vision, hearing, and vestibular senses among others. Cognitive changes that occur are because of the changes in the brain that accompany the ageing process. These include decreases in working and long-term memory and speed of processing (Park & Gutchess, 2006). With age also come changes in motivation, cognition and time perspectives (Fiske, Macrae, & Neil, 2012). All these changes have an impact on how older people perceive basic and higher levels of social perception. The following section discusses some of the main changes seen as a part of ageing, followed by the changes in social perception.

Physical changes

As a part of the normal ageing process, there is typically a general slowing down in all the organs of the human body. Saxon, Etten, and Perkins (2014) describe the various physical changes that occur. This includes characteristics such as reduced tolerance to stress, general slowness in physical activities and slowness in homeostatic equilibrium of internal aspects of the body such as blood pressure and acid balance. Changes also occur in the sensory areas as a part of normal ageing. Changes in vision and hearing are especially important, as they are a key aspect of social perception. In order to recognise an emotion, for example, the person needs to be able to see the facial expressions, gestures, and hear aspects of the voice that would communicate the emotion. Older people have reduced visual and auditory functioning, which is correlated with less time spent in physical activities (Anstey & Smith, 1999; Christensen, Mackinnon, Korten, & Jorm, 2001; Tsai et al., 2016).

These changes in the sensory functioning are related to both changes in the brain and the sensory apparatus such as the eyes or ears (Andersen, 2012).

Vision is important in the recognition of emotions as well as the complex elements of social perception. Studies have found changes in the eyes due to the process of ageing. For example, there are changes in the properties of the rods (Gosala, 2012; Jackson, McGwin, Phillips, Klein, & Owsley, 2006; Patryas et al., 2013), cones (Zhu, Brown, Rife, & Craft, 2006) and the retinal ganglion cells (Mann et al., 2005). Changes in vision in the ageing process include changes to light sensitivity (Richards, 1977), which also effects being able to detect an object (Seichepine et al., 2012).

The recognition of emotions or other complex aspects of social perception also rely on auditory aspects like prosody, tone and pitch. Age-related hearing loss, also known as presbycusis, is a common condition and can have multiple causes (Davis et al., 2016). Some of these causes include long-term exposure to long-lasting or loud noises. People who were exposed to loud noises in occupational settings for a significant portion of their lives often have hearing issues relating to this exposure (Basner et al., 2014). Other medical conditions such as diabetes, high blood pressure and using certain kinds of drugs like chemotherapy drugs can also lead to hearing loss (McKee, Stransky, & Reichard, 2018). Hearing loss has also been associated with changes in brain structure and function that accompany the ageing process (Lin et al., 2014). Changes in brain structure also lead to cognitive changes that are seen to accompany ageing.

Cognitive changes

Many studies demonstrate that as people age, their cognitive faculties decline steadily (Christensen et al., 2001; Insel, Morrow, Brewer, & Figueredo, 2006;

Rolls & Deco, 2015; Turner & Spreng, 2012). There has been some evidence of decline in processing speed and memory, but there have also been findings of intact crystallised abilities in older people (Harada, Natelson Love, & Triebel, 2013; Salthouse, 2012). More rapid decline in cognition is related to poor health, fewer years of education, less time spent in activities, and physical and medical illness like abnormal blood pressure (Christensen et al., 2001). Changes in memory are also seen in ageing. Short-term memory and episodic memory decline as people age (Rolls & Deco, 2015). Delayed free recall (remembering without a cue) (Price, Said, & Haaland, 2004), source memory (remembering where one learned some information) and prospective memory (remembering to do something later in the future) (Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013) are also seen to decline with age. However, some aspects of memory remain stable with age. This includes recognition memory (retrieving information with a cue), memory for temporal events and procedural memory (how to do things) (Harada et al., 2013).

Executive functions are a set of mental abilities that help us to attend to information, make decisions and judgements, and shift between different activities. By middle age, adults have already begun to experience decline in a range of executive functioning and memory domains (Turner & Spreng, 2012). As adults grow older, tasks related to executive functioning and working memory become increasingly difficult (Insel et al., 2006; Turner & Spreng, 2012). Decreases in executive functioning with age are seen in the reduced capacity to form new concepts, abstract thinking, response inhibition and mental flexibility (Oosterman et al., 2010; Salthouse, 2010; Singh-Manoux et al., 2012). Older people particularly struggle with activities that require quicker responses (Hayden & Welsh-Bohmer, 2012). They also find it difficult to perform verbal and

mathematical reasoning tasks, which suggests a decline in inductive reasoning (Singh-Manoux et al., 2012). In contrast, older people have no difficulties in being able to find similarities, describing the meanings of proverbs or in their reasoning capabilities with familiar material (Harada et al., 2013).

Changes in language abilities, which are frequently related to complex cognitive functions, are less of a problem with older people. Overall, language remains intact with age and some aspects, like vocabulary, improve with age (Park & Reuter-Lorenz, 2009; Salthouse, 2009), although there are exceptions. After the age of 70, the speed with which one is able to name a common object declines and this decline continues through the years. Further, verbal fluency, namely the ability to generate words that begin with a certain letter or naming as many animals as possible, declines with age (Salthouse, 2010; Singh-Manoux et al., 2012).

Like language, visuospatial skills remain intact with age (Harada et al., 2013). This includes being able to recognise familiar objects, being able to perceive an object, and spatial perception. The exception lies in visual construction skills (Salthouse, 2009). There is a gradual decline in the ability to assemble different parts in order to make a logical whole.

The changes in cognitive functions, as a part of normal ageing, have also been associated with increased vulnerability to financial fraud (Lichtenberg, Stickney, & Paulson, 2013; Spreng et al., 2017). This can obviously have an overwhelming effect on independence and wellbeing. James, Boyle, and Bennett (2014) examined the cognitive and psychological correlates of older people who are more susceptible to fraud. They studied 639 healthy older adults and assessed them on a wide range of neuropsychological assessments, including memory (episodic and semantic), language, attention and visuospatial ability. Depression,

wellbeing, personality, loneliness, social support and network size were also assessed. The authors found that older people who had a low cognitive function (with the exception of visuospatial functioning), lower psychological wellbeing and poorer health were more vulnerable to falling for financial fraud.

Motivational changes

Along with the concrete changes in physical and cognitive realms as a part of ageing, people's motivation also changes. The selective engagement hypothesis and the socioemotional selectivity theory are two major theories discussed below that have shown a relationship with aspects of social perception.

The selective engagement hypothesis is used to explain the adaptive aspects of behaviour in older adults. This theory, posited by Hess (2006), states that older adults select to engage in cognitive resources that are within the realm of their individual goals and ability to perform, which leads them to engage in activities that are more important to them (Hess, Queen, & Ennis, 2013). Lecce et al. (2017) found that older people's motivation to take part in social activities partly predicted their social network, especially how many friends they engaged with.

Consistent findings across nationalities and ethnic groups show fewer negative emotions and increased ability to control negative emotions in older people, as compared to their younger equivalents (Gross et al., 1997). Socioemotive selectivity theory posits that the awareness of limitations of time is related to the decreased importance placed on negative emotions as compared to positive ones. In other words, the reduced relevance of worries about the future leads to more understanding of one's emotions, leading to attention to positive emotional experiences. Older people hence show less negative emotion, have

fewer worries about financial and social events (Powers, Wisocki, & Whitbourne, 1992), fewer feelings of regret (Brassen, Gamer, Peters, Gluth, & Büchel, 2012) and in general experience less anger (Schieman, 1999). Another explanation is the positivity effect (Carstensen & Mikels, 2005), which is the bias of information processing that draws away from negatively valenced stimuli. In a study comparing young (ages 18 to 29), middle aged (ages 41 to 53) and older adults (ages 65 to 85) on a memory test that either had positive, negative or neutral images, Carstensen and Mikels (2005) found that as people grew older, they remembered positive emotional images better. When presented with two photographs–one positive and the other negative–older people had a tendency to avoid watching the negative one and to pay more attention to the positive emotion expression (Mather & Carstensen, 2003). However, different motivation theories have not been tested using more ecologically valid stimuli.

Emotion recognition

As we have already established in the preceding sections, the recognition of emotion is central to social communication. Difficulties in this area lead to difficulties in higher-order social perception skills as well. The implications for older people experiencing difficulties in emotion recognition are potentially large. Loneliness and isolation may influence the general wellbeing of people, and even affect mortality (Bath & Deeg, 2005; Fry & Debats, 2006). Therefore, the area of recognition of emotion deserves attention because of this potentially significant impact, especially in older adults.

There has been an increasing amount of literature produced on the recognition of emotions in older people. Older adults have a general bias towards positive emotions, which they were better at recognising (Moraitou, Papantoniou,

Gkinopoulos, & Nigritinou, 2013b; Moreno, 1993). Increase in age was associated with decreased accuracy in the recognition of negative emotions such as fear, anger (Calder et al., 2003; Malatesta, Izard, Culver, & Nicolich, 1987), sadness (Malatesta et al., 1987; Mill, Allik, Realo, & Valk, 2009) and disgust (Moraitou et al., 2013b; Moreno, 1993). However, the meta-analysis identified inconsistencies (Ruffman, Henry, Livingstone, & Phillips, 2008a). They included studies that looked into stimuli that were photographs, prosody, stories and videos.

The meta-analysis, found compelling evidence (a larger effect size) that older adults were worse at recognising some of the basic negative emotions of anger and sadness but showed no impairment in the recognition of fear or disgust through the medium of voices (Ruffman et al., 2008b). Contrary to the positivity bias, they found that older adults were worse at recognising happiness compared to negative emotions in certain modalities. The study examined some of the issues that make interpreting the findings of various papers difficult. One reason was ceiling effects, particularly in the recognition of happiness. Ceiling effects are often seen as a measurement limitation when people get the highest possible score on a test. Younger adults showed almost 98% accuracy in recognising happiness, making the difference between older and younger adults more attributable to the ceiling effect. Another concern about the findings was that some of the poor performances that were seen around the recognition of the emotions could be largely because of task difficulty. The limitations of using only simple and static two-dimensional stimuli, such as pictures and photographs, to assess emotion recognition (Calder et al., 2003; Moreno, 1993) is noted to increase in task difficulty.

More recently, there have been studies that have used other modalities such as voice and bodily cues to assess emotion recognition in older people. For

example, Ruffman, Murray, Halberstadt, and Taumoepeau (2010) used the Facial Expression of Emotion: Stimuli and Test (FEEST) (Young et al., 2002) to assess recognition of emotions through pictures, video clips of people using non-verbal emotional sounds (e.g., “grrr” for anger) or used emotional intonation while reading a passage. In order to assess bodily expressions, pictures of people displaying emotions through their body, but with their faces blurred, were presented to participants. They found that older adults were significantly worse at recognising basic emotions compared to their younger counterparts. Although the FEEST was a standardised test, there are no reliability and validity data for this test.

There are a few possible explanations as to why older people have been found to be worse at recognising emotions. Some of the changes seen in ageing studies are predominantly related to the recognition of negative emotions. As explained earlier in the biological basis of emotion recognition, multiple brain areas are responsible for the recognition of emotions. The ageing process includes changes in volume and changes in the activity of neurotransmitters. The cerebrum had approximately 10% decline in grey matter from ages 30 to 70, and a further reduction of about 11 to 12% by the age of 80 (Allen, Bruss, Brown, & Damasio, 2005). White matter in the brain (the myelin sheath that makes transmission of information faster) starts to reduce at an accelerated rate after the age of 50 accounting for poorer emotion recognition (O' Brien et al., 2002; Zheng et al., 2012).The volume in the amygdala declines with age (Allen et al., 2005; Gerritsen et al., 2015), which may cause older adults to struggle with recognising some emotions, especially fear and sadness.

The changes in brain activity with age are related to cognitive functioning, as seen on performance on neuropsychological assessments, however, findings

from studies examining the association between neuropsychological functioning and emotion recognition are inconsistent. MacPherson, Phillips, and Della Sala (2002) studied the relationship between age and social decision-making. They administered a series of dorsolateral prefrontal lobe neuropsychological tests and social perception tests (which largely target the ventromedial prefrontal lobe) to young adults (ages 20 to 38), middle-aged adults (ages 40 to 59) and older adults (ages 61 to 80). The social perception tasks involved a gambling task in order to detect social decision-making (gambling task), a test of ToM (Faux Pas Task), and an emotion recognition test (Ekman's emotion identification task). The dorsolateral prefrontal lobe tests were Wisconsin Card Sorting Task, the Self-Ordered Pointing Task and the Delayed Response Task. The temporal lobe tasks were the verbal paired associates subtest and the doors subtest. The doors subtest is a visual recognition task, thought to be sensitive to temporal lobe dysfunction. They found that social perception tasks mediated by the ventromedial prefrontal area were unaffected by ageing. On the other hand, older people did worse than younger adults on tasks mediated by the dorsolateral prefrontal area, which were largely memory and executive functioning tests. The lack of an association between cognitive functions and emotion recognition in older adults supports the idea of the automaticity of emotion recognition explained in the earlier sections.

Higher-order social perception changes in older people

Social perception appears to be important in maintaining meaningful relationships in older people. A study assessed ToM in 53 older adults who were between 60 and 85 years of age. The authors also examined the relationship between ToM and social motivation, and the participants' relationship with their relatives and friends (Lecce et al., 2017). Social motivation was measured using an item ("It is very

important that other people like me") from the social sensitivity subscale of the social skills inventory (Riggio, 1986). The Lubben Social Network Scale was also used to measure social relationships. The results showed that having meaningful friendships was dependent on good ToM skills, as well as high motivation to be liked by others. In other words, ToM affects meaningful relationships but social motivation appears to play an important role as well. The knowledge about how ToM changes in old age is an important issue.

As people grow older, they have more deficits in deciphering meaning and intent behind verbal communication, (i.e., ToM) (Henry, Phillips, Ruffman, & Bailey, 2013b). However, there have been mixed findings about the existence of deficits in ToM in older people. Some studies have found that older people performed worse on higher-order social perception tasks (Bernstein, Thornton, & Sommerville, 2011; Henry, Phillips, Ruffman, & Bailey, 2013a), others have shown that there were no differences (Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006; MacPherson, Phillips, & Della Sala, 2002), and yet others have found that these skills improved with age (Happé, Winner, & Brownell, 1998). One of the first studies of ToM in older people was by Happé et al. (1998). The performance of 19 healthy older people (Mean age = 73) and 52 younger students (Mean age = 21) were compared with a ToM test that the authors devised. The test consisted of 24 short stories that had double bluffs, mistakes, persuasions and white lies. The participants were questioned about inferences or intentions of the characters. Findings revealed that older people performed better than younger people on ToM.

On the other hand, no differences were found between older and younger participants. Some studies have found that there are no differences between the ageing process and higher-order social performance tasks (Keightley et al., 2006;

MacPherson et al., 2002). For example, Keightley et al. (2006), in an attempt to measure higher-order social perception, administered tests of emotion recognition (Japanese and Caucasian Facial Expressions of Emotion also known as, JACFEE) (Biehl et al., 1997) and ToM stories adapted from (Gallagher et al., 2000) tasks to 30 older (*M age* = 72.5) and 30 younger (*M age* = 25.7) adults. Older adults were slower in their responses to the tasks but were just as accurate as the younger participants were.

Numerous studies have found that various aspects of higher-order social perception skills change with age. Participants from three age groups (17 to 22, 51 to 59 and 60 to 85 years) were compared on a ToM task (a False Belief Task) to test if ToM abilities decrease with age (Bernstein et al., 2011). Middle-aged and older adults performed worse than the younger participants. A meta-analytic review (Henry, Phillips, & Von Hippel, 2014) of studies in ToM in older people looked at 23 datasets (790 younger and 672 older participants) and reviewed papers that used ToM tasks from different modalities, including verbal (stories), visual-static (pictures), visual-dynamic (videos), verbal and visual-static or verbal and visual dynamic (e.g., Faux pas). Across a wide range of participants, there was a consistent picture of older adults performing worse on ToM tasks. This generalised across the different modalities mentioned.

Another important question is whether the deficits in ToM were associated with age-related cognitive deficits. Simply based on the difficulty of the ToM tasks, Henry et al. (2014) concluded that the deficits in ToM in older people would be affected by the decrease in executive function. By definition, ToM tasks that have been used in studies, for example the Faux Pas or Reading of the Eyes tests, inflict greater demands on executive functioning processes (Bull, Phillips, & Conway, 2008). Similar studies have reported that the higher-order social

perception tasks depend upon multiple higher cognitive functions, which include working memory (Phillips, Channon, Tunstall, Hedenstrom, & Lyons, 2008), executive functioning (Bull et al., 2008) and language abilities (Uekermann, Channon, & Daum, 2006). On the contrary, a small number of other studies have found that social perception tasks such as emotion recognition, ToM and social decision-making were unrelated to cognitive function (Keightley et al., 2006; MacPherson et al., 2002).

There are a few points worth considering regarding the differences in the findings described above. One of these is the type of measure used. Another important difference between the previously described studies is the mode of presentation of ToM tasks. These include stories, pictures, videos or a combination of these modalities. The closer stimuli are to real life scenarios, the less demands they place on cognitive processes, thus showing less impaired performance (Light, 1991). The discrepancies between studies could be attributed to how they have defined ToM. Theory of Mind is operationalised in a few ways. For example, some tasks tap into affective states, emotions and feelings of ToM, and others focus on understanding cognitive states and intentions (Brothers & Ring, 1992).

Perception of complex emotional stimuli is not straightforward. Higher-order social perception, in terms of recognising information when presented in a counterfactual manner, is a skill that may also change as one gets older. For example, older people often chose logical answers to a joke and were frequently not able detect the humour in them (Uekermann et al., 2006). Two processes of higher-order social perception where counterfactual information is involved are the recognition of sarcasm and the recognition of lying.

Recognition of sarcasm.

The changes that are seen in older people in their ability to perform ToM activities suggests that they would also show differences in tasks requiring ToM skills.

Phillips et al. (2015) assessed the recognition of sarcasm by 40 young adults (18-39 years), 40 middle-age adults (40-64 years) and 36 older adults (65-86 years) by using the social inference-minimal subtest of the TASIT and stories of sarcasm adapted from Channon et al. (2007). The stories assessed direct and indirect sarcasm and included an equal number of control conditions. They also assessed emotion recognition using FEEST (Young et al. (2002), ToM (the Faux Pas Task by Stone et al. (1998)) and working memory as measured by an n-back test. Older adults showed more difficulty in recognising sarcasm as determined by performance on the TASIT subtest and the stories. The recognition of sarcasm was also dependent on the performance in emotion recognition tests, which reinforces the previous findings about the link between the recognition of emotions and sarcasm. Working memory abilities were significantly lower in older adults, but this did not affect their performance on the sarcasm recognition tasks.

Another study which assessed sarcasm in older people (Burdon, Dipper, and Cocks (2016), examined the difference between older (60 to 90 years) and younger (18 to 45 years) British participants on the TASIT. Once again, they found that older people performed worse on all the subtests of the TASIT. Although both age groups performed similar to the Australian norms, the unfamiliarity of the older participants to recognise the "Australian prosody" might be one of the reasons for their performance.

So far, there are only two studies that have looked into the ability of older people to specifically recognise sarcasm compared to their younger counterparts. Both of the studies described above used the TASIT in the assessment of recognition of sarcasm and both found that older people performed more poorly compared to younger adults. Similar studies in the field of assessment of lying have also been conducted.

Recognition of lying.

Most of the research on the recognition of lying has focussed on young adults. There have only been a few studies that have assessed the relationship between age and detection of lying.

Ruffman, Murray, Halberstadt, and Vater (2012) conducted a study with 60 adults in New Zealand–30 of them were young adults (aged from 17 to 26 years) and 30 of them older adults (age from 60 to 89 years)–to examine if older adults were less likely to be good liars. They hypothesised that this difficulty was because the older adults were being too transparent in their interactions and that they were not able to recognise emotions. They used a detection task similar to the one used by Frank and Ekman (1997), where 10 participants (actors) were videotaped while presenting arguments regarding a topical issue ("Stem cell usage in humans is ethical"), and half of those arguments were the opposite of the actors' personal views. In other words, they were asked to lie about their views and were monetarily reinforced if the research assistant (who was blind to the experiment) believed them. A truth and a lie from each actor was then compiled into a set of stimuli to be presented to the participants. The NimStim face stimulus set (Tottenham et al., 2009), which is a still photo facial emotion recognition test, was used to assess emotion recognition. Findings indicated that older adults were

worse at detecting a lie compared to younger adults. The authors also found that general accuracy of basic emotion recognition reduced with age and mediated lie detection. The use of more ecologically valid tests in the assessment of emotion recognition is one of its limitation.

Another study explored how the modality of presentation affected how accurate older people were at recognising lying. Stanley and Blanchard-Fields (2008) assessed 184 young adults and 210 older adults using emotion recognition and deception stimuli in audio, visual and audio-visual modalities. Further, in order to look at the relationship between cognitive abilities, participants were assessed on their verbal ability, fluid intelligence, working memory and visual acuity. Older people were worse at lie detection compared to younger adults, and did not seem to benefit from the audio-visual channels of presentation. In contrast, younger adults found the information given through both audio and visual channels were beneficial, as opposed to only audio or only visual modes. The recognition of fear and shame were significantly related to the recognition of lying. In other words, better emotion recognition led to better recognition of lying. The authors did not find a relationship between any of the participants' cognitive abilities and the detection of lying. Although the authors used a few cognitive tests to assess working memory, fluid intelligence and verbal ability, they lacked a robust neuropsychological assessment that may have helped answer some of the questions they had. They also acknowledge in their paper that the use of static stimuli in emotion recognition might reduce the external validity of their findings.

The role of cognition in the detection of lying in older people has largely been ignored in literature. Research with younger participants, including children, has pointed to the fact that the recognition of lying is complex in nature, and the neuropsychological functions associated with the recognition of lying include

executive functions such as planning ability and working memory, among others (Gombos, 2006). Like ToM, the recognition of lying shows a high likelihood of decline with changes in cognitive functions that accompany ageing.

In summary, social perception changes as we age. These changes are seen in basic processes like emotion recognition as well as higher-order social perception skills like ToM, which is involved in the recognition of particularly difficult counterfactual information. Research findings in the area of social perception and ageing are inconsistent, with some studies suggesting that there are no changes, small changes, significant decline, or even improvement in certain skills. Further, research in the area of cognitive correlates of higher-order social perception skills in older people is lacking. Changes in the volume of the brain are associated with changes in cognition and social perception skills. With the advent of degeneration of the brain, these changes become more obvious, and this knowledge is extremely important in guiding diagnostic and treatment processes. One of the most common neurodegenerative disorders in older people is dementia. Assessing social perception in dementia may help with the identification of specific dementia types as it may help in the diagnosis of types of dementia and aid in rehabilitation. Mild cognitive impairment has been identified as a condition that precedes dementia.

Mild Cognitive Impairment (MCI)

The term Mild Cognitive Impairment (MCI) was proposed by Peterson et al. (1997), who initially viewed this as a prodromal phase of dementia. However, it is now been seen as a risk factor of developing dementia (Klekociuk, Saunders, & Summers, 2016; Summers & Saunders, 2012). It is identified using

neuropsychological testing as well as by performance on various basic cognitive screening tests, including the Mini Mental Status Examination (MMSE) (Devanand et al., 2008). Mild cognitive impairment is characterised by (1) memory problems with a history of decline; (2) preserved cognitive functioning (not amounting to dementia); (3) intact activities of daily living; (4) no history of significant medical, neurological and psychiatric conditions; (5) no major risk factors for vascular disease; and (6) no history of alcohol abuse (Saunders & Summers, 2010). People with this condition have been shown to have deficits in memory tests, executive function tests assessing processing speed, planning, visuospatial tasks and language functions (Conde-Sala et al., 2012; Eppig et al., 2012; Marshall et al., 2011a; Summers & Saunders, 2012). These deficits are not at a level to qualify for a diagnosis of dementia.

A longitudinal study from 2001 to 2005 in the Aging, Demographics, and Memory Study (ADAMS) in the United States followed 180 older people and found that in 2002, an estimated 22.2% of people aged 71 and older had MCI (Plassman et al., 2008). Sachdev et al. (2015) reviewed 11 longitudinal prevalence studies from USA, Europe, Asia and Australia. The crude prevalence rate for MCI was 5.9%, which increased with age. The authors found a 4.5% prevalence in people aged between 60 and 69, 5.8% among 70 to 79 year olds and 7.1% in people between 80 and 89. There have been no published studies on the prevalence of MCI in New Zealand. There is an increase in the ageing population across the world. The increased prevalence of MCI and the considerable risk of them progressing on to dementia makes it a significant burden on society and health systems. Sachdev et al. (2015) report a widely-varied rate of MCI prevalence internationally, which has potential problems for the planning of public health and policies. One of the reasons why the prevalence rates are so

varied is because of the discrepancies in the diagnostic criteria of MCI. Consensus on the classification criteria, clinical presentation, cognitive and functional assessment is needed.

Diagnosis of MCI

The diagnosis of MCI has been an ongoing topic of debate and discussion. As a part of the first international working group on MCI, Winblad et al. (2004) recommended that for people to be diagnosed with MCI, they should not have dementia, their functional activities of daily living needed to be preserved or showing minimal impairment, and they should have several cognitive domains affected. Later, Petersen (2004) described subtypes of MCI that were either amnestic or non-amnestic. In order to clarify the criteria for the identification of MCI and its subtypes, Jak et al. (2009) reviewed the different classification of MCI based on neuropsychological assessments. By 2009, researchers were using neuropsychological assessments, clinical judgement, premorbid and clinical information from informants or a combination of these to diagnose MCI. Neuropsychological assessments typically consist of tests that measure several domains. Domains are broad cognitive processes that are distinct from one another and include memory, executive functioning, language, speed of processing or attention, and visuospatial functioning. The criteria for MCI consist of rules for cut-offs used for these tests. Jak et al. (2009) outlined five different neuropsychological criteria used to diagnose MCI. The *historical criteria*, also known as the *Peterson's criteria*, diagnosed people with MCI if they had a subjective memory complaint and their performance on a memory test was at least 1.5 SD below their age appropriate mean (Petersen et al., 1999). Petersen and Morris (2005) then adapted their criteria to include other domains and not just

memory. Therefore, for people to receive a diagnosis of MCI according to the typical or the Peterson criteria, they had to show 1.5 SD below the mean on any one test in at least one domain. The subsequent criteria did not need the person to have a cognitive complaint. The *comprehensive criteria* required the person to have at least 1 SD below the mean on two or more tests in a single domain (Heaton, Grant, & Matthews, 1992; Heaton, Heaton, & Psychological Assessment Resources, 2004). The *liberal criteria* stated that the individual needed to score below 1 SD on any one test of a domain. Lastly, the *conservative criteria* required that patients score 1.5 SD below the mean on at least two tests in a domain.

Complaints about subjective memory loss is used as a criterion for screening for MCI in some studies (Koontz & Baskys, 2005; Kurt, Yener, & Oguz, 2011; Seo, Kim, Choi, Lee, & Choo, 2017; Tangen, Engedal, Bergland, Moger, & Mengshoel, 2014). Subjective memory loss may be identified by the patient (Jean et al., 2010; Kotani et al., 2006) and/or an informant (Buckley et al., 2015; Leon et al., 2005; Petersen et al., 2005; Smith et al., 2010). This is typically assessed using a single question to establish memory complaint (e.g., "have you noticed your memory has become worse?") or via a questionnaire (e.g., Memory Assessment Clinics Questionnaire (Crook, Feher, & Larrabee, 2005). For example, Buckley et al. (2015) used a semi-structured interview to investigate various scenarios where the participant had lapses in memory and how they recovered from these. The authors of this study also used the Observer Memory Questionnaire with the informants to assess the informants' concern about memory lapses in their loved one. Assessment tools like the Prospective and Retrospective Memory Questionnaire (PRMQ), which consists of questions on the frequency of prospective and retrospective memory issues experienced by participants, have also been used in MCI studies (Ryu, Lee, Kim, & Lee, 2016).

However, studies have also found that subjective memory loss is not necessary or sufficient in determining if the person has MCI (Lenehan, Klekociuk, & Summers, 2012; Mitchell, 2008; Thompson, Henry, Rendell, Withall, & Brodaty, 2015).

The second, and one of the most important criteria for the diagnosis of MCI, is the exclusion of dementia. Most people use screening tools as a first point of assessment to rule out the possibility of dementia, to identify sub-clinical or normal cognitive functioning (Ahmed, De Jager, & Wilcock, 2012). The Mini Mental Status Examination (MMSE) (Arevalo-Rodriguez et al., 2015; Giseli de Fátima Dos Santos et al., 2016), Montreal Cognitive Assessment (MoCA) (Gagnon, Postuma, Joncas, Desjardins, & Latreille, 2010; Julayanont et al., 2015), a structured interview with the patient and/or their informant, the Dementia Rating Scale (DRS) (Bezdicek et al., 2015; Greenaway, Duncan, Hanna, & Smith, 2012), the Clock Drawing Test (Ehreke et al., 2011; Giseli de Fátima Dos Santos et al., 2016), the telephone-based neurocognitive screening tests (Ehreke et al., 2011), Addenbrooke's Cognitive Examination-Revised (ACE-R) (Yoshida et al., 2012) and computerised screening measures such as the Computer-administered Neuropsychological Screen for Mild Cognitive Impairment (CANS-MCI) (Tornatore, Hill, Laboff, & McGann, 2005) are all used. The cut-off used to determine MCI for the MoCA or the MMSE differed between studies from ≥23 (Buschert et al., 2011), ≥ 24 (Petersen et al., 2005; Rapp, Brenes, & Marsh, 2002; Smith et al., 2010), ≥26 (Koontz & Baskys, 2005), and between 24 to 28 (Doody et al., 2010). In order to determine the efficacy of screening MCI, Ahmed et al. (2012) compared the MoCA, MMSE, ACE-R and the CANS-MCI in assessing people with MCI and found that the MoCA and the ACER-R showed 90%

sensitivity in screening for people with MCI. A similar study evaluated the efficacy of the MoCA, ACE-R and the CANS-MCI conducted by de Jager, Ahmed-Ali, and Wilcock (2010). It was found that all of the tests, with the exception of the MMSE, were useful, but the authors recommended use of the MoCA and the ACE-R, as they are relatively shorter. Although screening tools provide a quick way of assessing general cognitive functioning, they are not necessarily useful or always accurate in identifying those with MCI, especially given the different use of cut-offs and the variety of tests available. On the other hand, screening tests often provide a quick way of looking into possible deficits which then need clarification through more extensive neuropsychological assessment. The next step in the process is to administer neuropsychological measures.

The diagnosis of MCI is made by administering a battery of neuropsychological tests and determining the level of impairment in each. Neuropsychological testing provides important information about the levels of impairment, the domain affected and can be used to monitor functioning across time (Cullen, Neill, Evans, Coen, & Lawlor, 2007). The neuropsychological tests measure domains such as executive functioning, memory, language, attention and visuospatial functioning. In the last few years, there have been a multitude of tests that have been developed to assess cognitive function. Further, the advent of computerised batteries have resulted in such assessments being used widely (Snyder et al., 2011), especially in a primary prevention setting, where there are often constraints on time spent with patients. There are no widely accepted guidelines about the tests that need to be used in the assessment of MCI, and the type and domains of tests vary across studies.

Another criterion of the diagnosis of MCI is related to unimpaired daily living skills. The most visible indicator of dementia is the loss of independence in activities of daily living. While some of these activities are basic, like eating, dressing oneself and bathing, others are complex like continuing careers, managing finances and travelling independently (Perneczky et al., 2006). In other words, people with MCI should be able to bathe, dress themselves and eat independently, while being worse at complex activities of daily living compared to cognitively intact older adults (Lindbergh, Dishman, & Miller, 2016). Almost all studies of MCI have assessed activities of daily living, either as a part of a general interview (Perneczky et al., 2006) or by using measures such as the Bayer Activities of Daily Living Scale (B-ADL) (Perneczky et al., 2006; Reppermund et al., 2011), the Instrumental Activities of Daily Living (IADL) (Marshall et al., 2011b; Ryu et al., 2016), the Structured Interview for Diagnosis of Dementia of Alzheimer type, Multi-infarct Dementia and Dementia of other Aetiology-Activities of Daily Living Scale (SIDAM-ADL Scale) (Luck et al., 2011), the Canadian Occupational Performance Measure (COPM) (Giseli de Fátima Dos Santos et al., 2016) and the Groningen Activity Restriction Scale (GRS) among others.

Over the last decade, there has been research in neuro-imaging studies to determine biomarkers of MCI. These include examining functional changes in a person's brain using Positron Emission Tomography (PET) (Moulin et al., 2007), electroencephalography (EEG) (Timothy, Krishna, & Nair, 2017; Tóth et al., 2014) or magnetoencephalography (MEG) (Amezquita-Sanchez, Adeli, & Adeli, 2016; Bruña et al., 2012) while participants performed cognitive tasks like working memory tests. This research is still in its early stages and there is no clear consensus on the biomarkers of MCI.

Subtypes of MCI

As mentioned above, MCI encompasses a wide range of types of cognitive deterioration. This could include executive functions such as planning, reasoning, memory functions such as working memory, visuospatial functions and language functions. Thus, the neuropsychological profiles of people with MCI are very diverse, and this has given rise to the study of various subtypes: single domain amnestic MCI (sda-MCI), multiple domain amnestic MCI (mda-MCI), single domain non-amnestic MCI (sdna-MCI) and multiple domain non-amnestic MCI (mdna-MCI) (Petersen, 2004). The two main subtypes are diagnosed as shown in Table 1.

Table 1. Description of subtypes of MCI

Subtype of MCI	**Description**
Amnestic-MCI(a-MCI)	Informant-corroborated subjective complaint of declining memory functioning
	Objective memory impairment
	No objective attention, working memory or semantic language impairment
Non-amnestic-MCI(na-MCI)	Informant-corroborated subjective complaint of declining cognitive functioning
	No objective memory impairment
	Objective attention, working memory or semantic language impairment

Adapted from Saunders and Summers (2010)

Table 1 shows amnestic and non-amnestic subtypes. Single domain and multiple domain subtypes are defined based on the number of domains affected. For example, people with a memory domain and a non-memory domain impaired would be classified as mda-MCI. Similarly, people with more than one non-amnestic domain impaired would be classed as mdna-MCI.

Sachdev et al. (2015) used unified criteria in order to determine prevalence rates of MCI and its subtypes in 11 studies across the USA, Europe, Asia and Australia. These criteria included studies that showed 1.0 to 2.0 SD below the mean on at least one neuropsychological domain, the presence of a memory complaint, the absence of dementia and nil or minimum functional impairment. They explored two subtypes–a-MCI and na-MCI–and no information regarding single or multiple domains was given. They found that naMCI was more prevalent (3.9%) than aMCI (2%). They found naMCI was most prevalent in men between ages of 70 and 79, compared to men between 60 and 69 years old. For women, naMCI was greater in people between the ages of 80 and 89 compared to 70 and 79-year-olds.

Progression to dementia

The study of people with MCI is important, because people with MCI have been seen as having a greater risk of leading to dementia, and for many people, it is an intermediate stage between normal ageing and dementia. Epidemiological and longitudinal studies have found that there is an increase in rates of conversion from MCI to dementia over time. The most common type of dementia is Alzheimer's disease (AD), which constitutes 10.6 to 153 per 100 000 of the population. Frontotemporal dementia constitutes 1 to 15.4 per 100 000 of the population (Lambert et al., 2014), making it the second most common type of dementia (Ballard et al., 2009). The development of symptoms among different

types of dementia is varied. The following subsections will describe the main types of dementia, the early symptoms and the progression of MCI to the particular subtype.

Progression to Alzheimer's disease

The pathological hallmark of AD are amyloid plaques and neurofibrillary tangles, which affect the cortex of the brain (Mathis, Wang, & Klunk, 2004). In AD, the tau protein is abnormal and does not support the microtubule (Perry, 2006). A definite diagnosis of AD can only be made be made post mortem (Thal & Braak, 2005). However, a provisional diagnosis is based on symptoms and some imaging techniques. Usually, this begins with a clinical interview with information collected from informants or caregivers. Early symptoms of AD are memory loss, difficulty performing familiar tasks, problems with language, problems with abstract thinking and disorientation in time and place (Mundt, Kaplan, & Greist, 2001).

The course of the disease is insidious or starts slowly and gradually gains momentum. The annual conversion rate from MCI to AD in the US between the years 2000 and 2015 was 40% per year per person (Chen et al., 2017). Since memory impairments are one of the hallmarks of the disease, it is not surprising that people with amnestic MCI, particularly multiple domain, have a higher risk of developing the Alzheimer's type of dementia (Michaud, Su, Siahpush, & Murman, 2016; Tzeyu, Dejun, Mohammad, & Daniel, 2017). A meta-analytic study found that 11.7% of single domain amnestic MCI progress on to AD, 12.2% multiple domain amnestic MCI converted to AD and a relatively smaller 4.1% of non-amnestic MCI converted to AD (Mitchell & Shiri-Feshki, 2009). Lee, Ritchie, Yaffe, Cenzer, and Barnes (2014) followed 382 participants with

amnestic subtype (95% single-domain, 5%-multiple domain) of MCI for three years. These participants were enrolled in the Alzheimer's disease Neuroimaging Initiative (ADNI). The mean age of the group at enrolment was 75 years old. They found that 43% of these participants progressed to Alzheimer's disease in three years. They also assessed predictors of risk for AD. These included list-learning difficulties, constructional difficulties like drawing a clock and functional issues such as shopping alone and forgetting appointments. A few behavioural changes such as stubbornness about accepting help, and anxiety around separation from caregivers were also noted.

It may be prudent to conclude, based on these studies, that people with subclinical deficits in memory tests were more prone to developing AD as opposed to other types of dementia. Although most longitudinal studies like the ones listed above have attempted to follow the course of progression from MCI to AD, longer time lines would contribute to a better understanding of the possibly slower progression in some people. Studies have concluded that some good predictors of progression from MCI to dementia are neurological biomarkers (Csernansky et al., 2000; Dubois et al., 2007) such as cerebrospinal fluid markers (Blennow & Hampel, 2003; Mattsson et al., 2009; Popp et al., 2015), neuropsychological assessments (Ewers et al., 2012) and brain imaging (Du et al., 2001; Ewers et al., 2012).

Progression to frontotemporal dementia

Frontotemporal dementia (FTD) is progressive atrophy in frontal and temporal lobes of the brain (Kril & Halliday, 2004). Frontotemporal dementia is the second most common form of dementia, and has an earlier onset, typically before the age of 65 (Karageorgiou & Miller, 2014), with people reporting some symptoms in

their 50s or 60s and sometimes even earlier in their 40s and 30s (Ratnavalli, Brayne, Dawson, & Hodges, 2002). Frontotemporal dementia is usually subtyped as either a behavioural or language variant. As the names suggest, the subtypes are diagnosed depending on the type of impairment (Rascovsky et al., 2011). The behavioural variant of FTD is of particular interest, as it is associated with subtle changes in social cognition before the onset of other noticeable changes. People with behavioural variant FTD (bvFTD) usually lack insight into their problems (Rosness, Haugen, Passant, & Engedal, 2008; Sayantani & Carol, 2013), making it harder to identify early or aid treatment. Due to the lower age of onset and behavioural changes, these people are often misdiagnosed as having neuropsychiatric symptoms such as mood disturbances, psychoses, compulsions, anxiety symptoms and agitation (Rongve et al., 2016). Another hallmark of FTD is its relative speed of progression as compared with AD. Roberson et al. (2005) followed 177 people with FTD and 395 people with AD. They found that people with FTD progressed faster than people with AD. Some of the early symptoms of FTD are abnormal social behaviours, minor criminal offences such as shoplifting, changes in personality, atypical depression and preference for sweeter foods (Neary et al., 1998; Passant, Elfgren, Englund, & Gustafson, 2005; Swartz et al., 1997; Woolley, Khan, Murthy, Miller, & Rankin, 2011). Apathy or the lack of energy, enthusiasm or concern are also common early symptoms of FTD (Shinagawa, Ikeda, Fukuhara, & Tanabe, 2006), which may be often confused with depression and treated accordingly (Bott, Radke, Stephens, & Kramer, 2014).

In neuropsychological testing, people with FTD show deficits in executive functioning in the early stages and in language functions later on (Bott et al., 2014; Rascovsky et al., 2011), although deficits in either of the domains are

important markers. Smeding and de Koning (2000) found that executive functioning tests such as the trail making tests, digit symbol tests and card sorting tests were good markers of impairments in executive function in people with FTD. Impairment in the language domain of a neuropsychological assessment has been also recommended as a distinguishing factor in the diagnosis of MCI and AD from FTD (Beck, Schmid, Berres, & Monsch, 2014).

On the other hand, there are some conflicting reports about episodic memory being affected in people with FTD. Hornberger, Piguet, Graham, Nestor, and Hodges (2010) found that people with bvFTD had intact episodic memory compared to the other variants of FTD. This is an important factor in the diagnosis of FTD, as people may often be misdiagnosed as a result. However, it is to be noted that although episodic memory is preserved in the initial stages of FTD, it may get worse as the disease progresses (Libon et al., 2007). Given that FTD, especially the bvFTD, results in changes in social perception, it has been suggested that social perception assessments such as the Social Cognition and Emotional Assessment (SEA) be used to aid diagnosis (Funkiewiez, Bertoux, de Souza, Lévy, & Dubois, 2012).. The SEA consists of subtests from other sources, including five subtests assessing emotion recognition, theory of mind, behavioural control and apathy.

Not surprisingly, when looking at progression rates from MCI, the non-amnestic subtype of MCI was more likely to progress to FTD (Ferman et al., 2013; Rosenberg et al., 2011; Yaffe, Petersen, Lindquist, Kramer, & Miller, 2006). Studies examining the progression of MCI have been conducted on the amnestic MCI subtypes, and there is a need for more longitudinal studies in the field.

There have been a few studies that discuss the conversion from MCI to FTD (FTD-MCI). The first study, conducted by de Mendonca, Ribeiro, Guerreiro, and Garcia (2004), describes short case descriptions of their seven participants who were diagnosed with FTD-MCI according to the author's proposed criteria. In addition to showing impairment in at least one executive functioning test (attention, language, graphomotor or conceptual thinking), the criteria included early symptoms of apathy, disinhibition, irritability, messiness, obsessions, lack of concern for others and aggressiveness. These patients were followed up for almost two years, and six out of the seven patients had progressed to FTD. The authors used neuropsychological measures that assessed a wide range of cognitive domains. The selected patients had difficulties that were largely executive functioning deficits, attention, and motor and language skills. The obvious limitation to this study is the small number of participants selected. In addition, the initial criteria for selection of participants suggest that they already displayed symptoms of FTD. Although not an inclusion criterion, five out of the seven participants studied had frontotemporal atrophy that was picked up from imaging measures, and two of them had a family history of frontotemporal dementia. In other words, they were not typical MCI patients but already showed signs of FTD. Another study by Yaffe et al. (2006) followed 43 people with multiple domain amnestic MCI, 250 people with amnestic MCI and 34 people with single domain non-amnestic MCI, longitudinally for five years. They found that all of the 34 participants (100%) who had a diagnosis of a single non-amnestic subtype of MCI progressed to FTD.

The detection of people who might develop frontotemporal dementia is very important, as medical management is different from that of the AD type. Selective serotonin reuptake inhibitors (SSRIs) have shown to improve

psychological and behaviour symptoms in people with FTD (Moretti, Torre, Antonello, Cazzato, & Bava, 2003). Further, the early diagnosis of naMCI among those that may develop into FTD may help in explaining the personality and psychological symptoms to the caregivers. With its quicker progression compared to other kinds of dementia, early identification is paramount. These, along with other reasons like legal considerations, competency decisions, as well as follow-up care make the early diagnosis of FTD beneficial. There is an increasing necessity for other tests sensitive enough to identify early signs of changes in behaviour or social perception difficulties.

Progression to other kinds of dementia

Studies have examined progression of MCI to other kinds of dementia such as vascular dementia and dementia with Lewy bodies (Fujishiro et al., 2012; Zanetti et al., 2006). In a study by Yaffe et al. (2006), 50% of participants with amnestic MCI, 42% with multiple domain MCI and 8% of participants with single domain non-memory MCI progressed to vascular dementia. Few studies have been performed on the progression of MCI to dementia due to Lewy bodies.

Non-progression of MCI

Although people with MCI have an increased risk of dementia, not all do develop the disease. Some people with MCI stay the same, or revert back to normal cognition on neuropsychological tests (Brodaty, Connors, Ames, & Woodward, 2014). An Australian longitudinal study by Brodaty et al. (2014) followed 185 people with MCI at 3, 6, 12, 24 and 36 months and were assessed on their functioning ability using the Functional Autonomy Measurement System (SMAF), neuropsychiatric symptoms like delusions, agitation and anxiety, and

cognitive functions using the MMSE. They found that only 30% of the participants had developed dementia within three years, which meant that more than half of their population sample remained the same or may have reverted to normal. Predictors of a higher risk for developing dementia included older age, lower cognitive ability at baseline, and faster decline in cognitive ability over the first six months of follow up. Further, the diagnosis and progression was based on the MMSE, which does not necessarily capture the wide range of cognitive functions shown by the participants. Some items of the Functional Autonomy Measurement System (SMAF), which is rating scale that measures activities of daily living, communication, mobility and mental functions is highly prone to the clinical judgement of the rater, which was not measured in the study.

In summary, although studies have found that MCI progresses to different types of dementia, it is a small percentage of people who progress, with most others remaining the same or reverting to normal cognitive functioning. This indicates that MCI cannot just be seen as a prodromal phase of dementia. Mild cognitive impairment needs to be seen as a risk factor to developing dementia, and other factors such as medical conditions, psychosocial stressors, neuropsychiatric conditions and subjective complaints need to be assessed (Klekociuk et al., 2016). Clarity in diagnostic criteria, classification of subtypes and further longitudinal studies using robust neuropsychological measures are required to make accurate assumptions regarding people who are at greater risk of progression to dementia. In addition, studies have largely focused on amnestic MCI, which is more likely to progress to AD, and there is a need for studies that focus on na-MCI.

Social perception in MCI

There is some evidence that higher-order social perception is dependent on cognitive abilities. Further, it has also been seen that healthy older people show more deficits in social perception than younger people, but these deficits reduce if the tasks used to measure social perception are similar to real life situations. This further supports that the changes in cognition in MCI could lead to difficulties in social perception. Changes in subtle social perception skills may occur as early symptoms in certain types of dementia, for example bvFTD.

Social perception skills are an important factor in forming and maintaining interpersonal relationships, which in turn affects wellbeing and quality of life. Changes in social perception as seen in AD, FTD and others may indicate these changes begin at an earlier stage, namely MCI. More recently, there have been a few studies in the area of social perception, such as emotion recognition and ToM, in MCI.

Emotion recognition in MCI

Research in the area of the recognition of emotion in MCI is still relatively new and developing. However, a number of studies have found that people classified with MCI perform poorly in the recognition of certain emotions (Anderson, Simpson, Channon, Samuel, & Brown, 2013; Fujie et al., 2008; Henry et al., 2009; McCade, Savage, Guastella, Lewis, & Naismith, 2013; McCade, Savage, & Naismith, 2012a; Pietschnig et al., 2015; Teng, Lu, & Cummings, 2007; Weiss et al., 2008; Yang et al., 2015).

The latest recent review by Bora and Yener (2017) examined published articles of social perception in MCI which included the recognition of emotion.

They evaluated ten articles that examined emotion recognition in MCI. The results of the meta-analysis showed that people with MCI were impaired in their recognition of emotions (medium effect size), particularly with the recognition of fear (Henry et al., 2009), sadness and anger (Fujie et al., 2008; McCade, Savage, Guastella, Hickie, et al., 2013). The recognition of disgust (Henry et al., 2008), happiness (Sarabia-Cobo, García-Rodríguez, Navas, & Ellgring, 2015) and surprise (Bora & Yener, 2017) was relatively preserved in people with MCI. Similar results were found by another meta-analysis which was carried out by McCade et al. (2012), who reviewed six studies of emotion recognition in MCI. The detection of negative emotions such as anger, sadness and fear was more affected in MCI. One of the reasons why people with MCI performed poorly on recognition of emotions was also attributed to their cognitive changes.

The recognition of emotions in people with deficits in two or more domains of cognitive functions, namely multiple domain MCI was associated with a significant decline in the performance in emotion recognition (Bora & Yener, 2017). In fact, the effect size was similar to that documented in a meta-analysis on emotion recognition in AD (Klein-Koerkamp, Beaudoin, Baciu, & Hot, 2012). These studies found that the more cognitive deficits a person had, the more likely they were to have poor performance on emotion recognition tasks. One of the limitations for these studies was the choice of the assessment of the recognition of emotions; they used static visual stimuli to assess emotion recognition. The apparent deficits in social perception may reduce if the stimuli were closer to real life situations with the inclusion of other cues such as prosody and contextual information. One of the other limitation of current studies in emotion recognition is that positive emotions are largely underrepresented, with most studies assessing more negative emotions than positive ones. Further, the deficits in emotion recognition and how they affect

everyday living, including social relationships and quality of life, remains to be known. In addition, only a few studies have examined social perception in various subtypes (single and multiple domain impairments) of MCI. Developing further knowledge in this area may provide more consistent information regarding the relationship between cognitive abilities and emotion recognition.

There are a smaller number of studies that have found no differences between people with MCI and healthy controls in the recognition of emotions (Bediou et al., 2009). A small sample (10) of people with aMCI were compared to people with mild and moderate AD and FTD (Bediou et al., 2009). Morphed photographs displaying happiness, fear, anger and disgust were used to assess emotion recognition. Peterson's revised criteria were used to diagnose amnestic MCI. Information regarding the number of domains impaired was not provided. The participants with FTD and AD showed impairment in the recognition of negative emotions, and the people with a-MCI did not show any impairments. The small sample size, lack of inclusion of other subtypes of MCI and the use of a test that was not psychometrically sound make these findings difficult to generalise.

Of the research that has been conducted, most has focused on a-MCI. We now know a-MCI has a higher likelihood of converting to AD than na-MCI. Although AD does include changes in social cognition, other types of dementia, especially FTD, have more deficits in social perception skills. It is thus important to study people who have na-MCI. The study by McCade, Savage, Guastella, Lewis, et al. (2013) assessed emotion recognition in naMCI. Eighteen people with non-amnestic multiple domain MCI, 19 with amnestic multiple domain MCI and nine healthy controls were recruited from a clinical setting at the Brain and Mind Research Institute in Sydney, Australia. They were assessed on their cognitive abilities (Premorbid IQ, working memory, verbal learning and memory, visual

memory, language, visuospatial skills, processing speed and executive functioning), emotion recognition (FEEST) and recognition of emotional content in complex scenes (The Movie Stills Task by Losh et al. (2009)). Participants with naMCI did not show any deficits in emotion recognition. In contrast, people with aMCI had deficits in recognition of all emotions on the Movie Stills Task and on the recognition of anger on the FEEST. Further, controlling for cognition, people with aMCI did not show deficits in the recognition of emotion. The other studies that have reported no deficits in emotion recognition in people included mainly people who met the criteria of single domain MCI.

People with MCI show deficits in their recognition of emotion, particularly in people with multiple domain a-MCI. By choosing more ecologically valid tests of recognition of emotions, we may be better able to examine how people with MCI perform on social perception tasks without the challenge of a cognitively difficult task. This may reduce the effect of cognitive load on the task, thus giving more insight into the recognition of emotions in MCI. The deficits seen in the recognition of emotion in MCI may also affect one's capacity in more complex social perception skills.

Higher-order social perception skills in MCI

Research on social perception in MCI is still in its infancy. Higher-order social perception deficits such as ToM and recognition of sarcasm, are documented in research (Baglio et al., 2012; Gaudreau et al., 2015b; Maki, Yamaguchi, Koeda, & Yamaguchi, 2013; Moreau et al., 2015; Poletti & Bonuccelli, 2013a). Only one study has found no deficits in the recognition of higher-order social perception skills in people with MCI (Dodich et al., 2016).

In the meta-analysis discussed above (Bora & Yener, 2017), seven published papers examined complex social perception skills in MCI. Most of the studies assessed ToM or mentalising skills and just one studied the recognition of sarcasm. ToM was assessed using False Belief Tasks and the Reading the Mind in the Eyes Test. Sarcasm was studied using the Metaphoric and Sarcastic Scenario Test (MSST) (Adachi et al., 2004). People with MCI had poorer performance in tasks that required ToM abilities (medium effect size). The effect size increased (*d* = 0.89) when they analysed people with multiple domain aMCI and reduced (*d* = 0.39) with single domain MCI. Thus, widespread cognitive impairment was related to more impairment in complex social perception tasks. Two out of the seven studies found that the deficits were specifically for the second order ToM skills (Baglio et al., 2012; Gaudreau et al., 2015a) (inferring what somebody might think about another person's mental state). These findings suggest that cognitive abilities and complex social perception skills are related.

Assessments that capture the recognition of counterfactual information (i.e., sarcasm) can be an important source of information about ToM abilities. One of the limited studies that was conducted on the recognition of sarcasm in people with MCI was by Maki et al., 2013. Forty-two people with aMCI (mean age, 74), 104 older healthy controls (mean age, 72), 30 with mild AD (mean age, 78) and 31 young healthy participants (mean age, 19) took part and completed the Metaphoric and Sarcastic Scenario Test (MSST) (Adachi et al., 2004). This tool had been developed initially to discriminate people with high functioning pervasive developmental disorders from ADHD in Japanese children. It consists of five metaphoric and five sarcastic sentences. The understanding of these sentences by participants was scored from 1 to 4 and was categorised as literal interpretation, following just a part of the sentence, misunderstanding of the sentence, and a

completely incorrect answer. People with aMCI showed slight declines in the comprehension of sarcasm and this decline was significantly larger in people with AD. These findings indicate that the comprehension of sarcasm appears to depend on cognitive abilities as well. However, this has not been formally examined in any studies to date.

One of the few studies that have found no differences in higher level social perception tasks in people with and without MCI was carried out by Dodich et al. (2016) in an experimental study. Dodich et al. (2016) administered a Story-based Empathy Task (SET) to participants with AD (12), bvFTD (20) and amnestic MCI (15). Participants with MCI did not differ from the healthy participants in their performance on the aspects of ToM.

In conclusion, the research in social perception is limited. People with more deficits on cognitive tests are more affected in their recognition of emotions. The materials used to date are artificial and cognitively demanding and the poor performance on these tests reflects broader cognitive changes.

Summary and aims of the thesis

Social perception is an important aspect to developing and maintaining good social relationships, which in turn foster positive wellbeing and mental health. Emotion recognition is the first step in processing higher-order complex social perception skills, such as ToM and recognition of sarcasm and lying. These complex social perception abilities are vulnerable to changes in our cognition, which occur due to ageing as well as other neurological and developmental conditions.

With the increase in the ageing population, MCI is likely to be increasingly prevalent. Mild cognitive impairment by definition is associated with cognitive decline. Currently, it is unclear which aspects of neuropsychological functioning

are linked with successful social perception. Given the importance of intact social perception in quality of life and wellbeing, there is a need for research to examine social perception in MCI.

To date, assessment of emotion recognition has largely used static pictures and unrealistic videos. These may be inaccurate measures, as interactions between people involve various other cues such as vocal tone and gestures. Some studies have examined ToM and recognition of sarcasm in dementia, but there are no studies on MCI. The same is true for the recognition of lying. With the possibility of an increase in vulnerability and risk of fraud, as well as the loss of social activity, assessing the recognition of higher-order social perception skills such as sarcasm and lying is important. The identification of deficits in social perception in a more ecologically valid way is paramount in aiding interventions, and thus improving mental health. There is, therefore, a need for research on the nature of social perception in the ageing population and its association with cognitive functions.

Aims and Hypotheses

The use of ecologically valid tests helps to generalise the results to everyday situations.

i) The first aim is to examine social perception in those with and without MCI.

   a. It is hypothesised that participants with MCI would be worse than participants without MCI at all aspects of social perception, particularly the higher-order processes of recognition of sarcasm and lying.

b. It is also hypothesised that a greater proportion of people with multiple domain MCI will have deficits in social perception compared to people without MCI.

ii) A second aim was to examine the association between social perception and neuropsychological functioning.

a. It is hypothesised that the recognition of emotion will not be related to higher-order cognitive processes, including executive functioning, language and memory.

b. It is hypothesised that the recognition of emotion would affect the accuracy of the recognition of higher social perception tasks– sarcasm and lying.

c. It is hypothesised that deficits in paradoxical sarcasm will be related to language difficulties.

d. It was hypothesised that the recognition of lying would correlate to some of the higher-order cognitive functions, especially executive functions and language.

iii) The third aim of the current study was to examine the differences between the recognition of positive and negative emotions among older people.

a. It was hypothesised that older adults would perform worse on the recognition of negative emotions, compared to the recognition of positive emotions.

iv) The final aim of the study was to examine the relationship between social functioning and social perception

a. It was hypothesised that people with deficits on social perception will have lower social functioning

Chapter 2-Methods

Ethics

Ethics approval for the study was obtained from the School of Psychology Research and Ethics Committee at the University of Waikato (13:02) and the Health and Disability Ethics committee (HDEC) (16/NTA/68) to recruit participants through the Waikato and Bay of Plenty District Health Boards (DHB).

Participants

Recruitment of participants for this study was conducted in two ways–from the community and through the local DHBs. The first phase of the community recruitment included all people above the age of 50 while the second one included participants who had complaints of changes in their cognition (advertisements in appendix A and B).

Initially, participants were recruited via advertisements in various places in the community such as at laundromats, GP practices, supermarkets, shops, around 20 rest homes in Hamilton and Cambridge, online community notice boards, social and cultural clubs and social media websites such as Facebook. The study was also advertised and published in the local newspapers in the Waikato region.

The inclusion criteria for the study were people above the age of 50, English speaking (as standardised administration of tests requires fluency in English), and with adequate visual and auditory functions along with hand mobility, as the tests required these faculties.

Participants interested in taking part completed three screening tests with the following cut-offs. The participants that scored below 26 on the MoCa were excluded to rule out dementia or other possible neurological problems. They were excluded if they had a score of ≥4 on the Geriatric Depression Scale and ≥8 on the Alcohol Use Disorder Identification Test to rule out depression and alcohol abuse respectively. Along with these, there were other exclusion criteria.

Exclusion criteria included participants who had a formal diagnosis of dementia or had a history of significant traumatic brain injury or any other neurological illness. The presence of a history of traumatic brain injury was determined by asking if the participant had been hospitalised following a head injury. Participants under treatment for depression, anxiety disorders or any other psychiatric illness were also excluded from the study.

Of the 60 participants (see Figure 2.1) who initially volunteered to take part, three were not eligible. Of these, one had a high AUDIT score, one of them was diagnosed and undergoing treatment for depression and one of them had a low score on the MoCa.

We then advertised for participants above the age of 50 who had a subjective complaint of decline in cognitive functioning, including but not exclusive to memory functioning. Of the 49 people (see Figure 2.2) who responded to the second advertisement, 39 participants were eligible and completed the assessments. Of the 10 volunteers who were ineligible, one participant withdrew due to lack of time, one participant had a head injury, two participants had a low MoCA score and six participants had a high AUDIT score.

The final community sample consisted of 96 participants (see Figure 2.3); 27 (28.13 %) were male and 69 (71.9 %) were female. Their age ranged from 50 to 83 years (M = 62.74, SD = 8.1). Fifty-one (53.13%) of the participants were

married, 19 (19.8 %) were divorced, eight (8.3 %) were in de facto relationships, ten (10.42 %) were widowed, four had never been married and four were separated from their partners. Seventy-nine (82.3 %) were New Zealand European, seven (7.3 %) were of New Zealand or Cook Island Māori descent and the others were from other ethnicities which included Australians, English, South African, South African-Indian and Irish.

Additional participants were recruited through the Older Persons Rehabilitation Services (OPRS) and the Mental Health Service for Older People (MHSOP) at Waikato District Health Board (WDHB) and Bay of Plenty District Health Board (BOPDHB). The inclusion criteria for this sample was a provisional or definite diagnosis of mild cognitive impairment (MCI) given in the last 8 years by a general physician, geriatrician or a psychologist. This list was generated from the WDHB and the BOPDHB. Exclusion criteria involved the presence of a diagnosis of dementia, regular use of illicit substances, history of neurological conditions including stroke, head injury and other conditions, and if they were undergoing treatment for a serious psychiatric condition. Although all the measures were administered to the clinical sample, the MoCA and GDS were not used as screening tools for exclusion of participants, as they had received a formal diagnosis of MCI.

A letter (see Appendix E) explaining the study along with the information sheet (see Appendix F) was mailed to eligible participants and followed up with a phone call a week after posting the letter.

Ninety participants (see Figure 4) with a diagnosis of MCI were identified from the WDHB clinical files, and ten participants were from the BOPDHB. Of these, 14 had incorrect contact details (either wrong phone numbers or their letters were returned because of wrong details), one was deceased, eight had developed

dementia, two had multiple head injuries, and 54 were not interested in taking part in the study. Out of the 21 consenting and eligible participants, 19 were from the WDHB and two from the BOPDHB. Eleven (52.4 %) were male and ten (47.62 %) were female. Their age ranged from 46 to 88 (*M* =72.24, *SD*=10.4). Eleven participants were married, one was divorced, seven were widowed and one had never been married. Sixteen participants identified as New Zealand European, three were Māori, and there was one each from Dutch and Swedish descent.

In addition to the participants, informants (when available) were contacted to complete two questionnaires (explained below) as well as a few questions about some demographic information. Of the 96 participants from the community sample, questionnaires were completed with 60 informants. Their age ranged from 20 to 84 years (*M* =57.63, *SD*=14.7). Thirty-four of the informants were female and 26 were male. Thirty-six of them were either husbands, wives or partners of the participants, 11 were children of the participants, five of them were friends of the participants, and there were two colleagues, two siblings and all the rest were other relatives such as cousins. Fourteen out of the 21 participants from the DHB sample provided informant questionnaires as well. Their ages ranged from 35 to 86 years (*M* =62.21, *SD*=15.7). Most of the informants (10) from the DHB sample were either husbands, wives or partners of the participants, and four were the children of the participants.

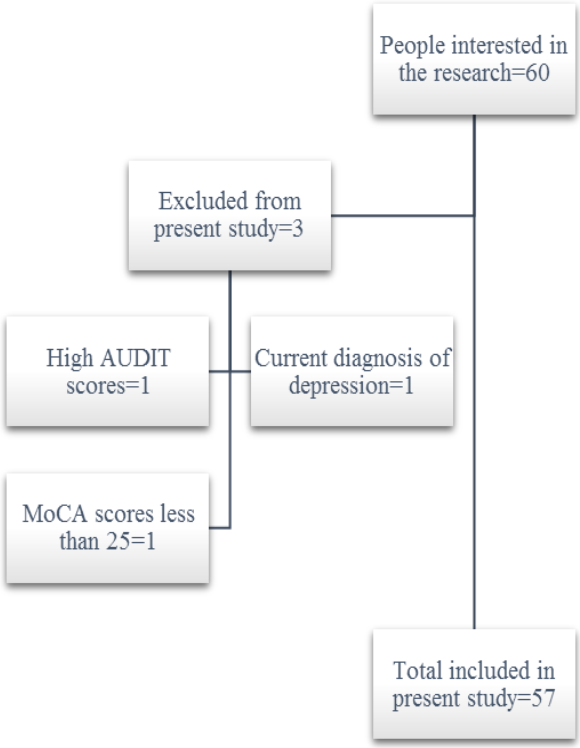

Figure 2. 1 Flow chart of initial community recruitment

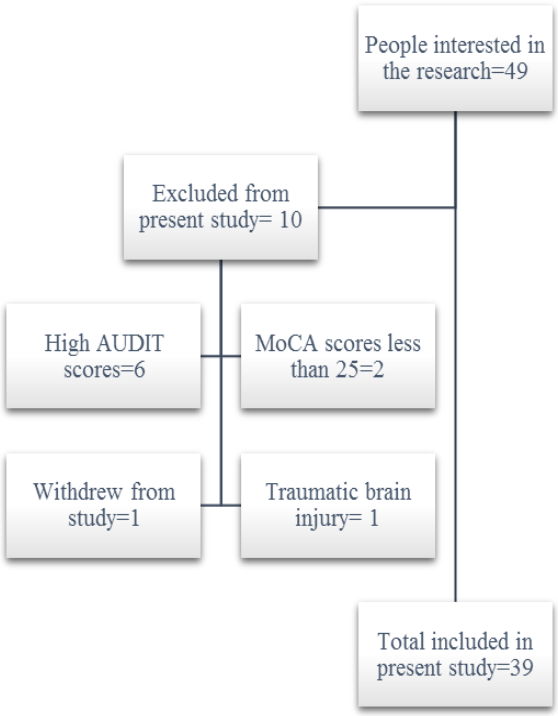

Figure 2. 2 Flow chart of community recruitment of participants who had a cognitive complaint

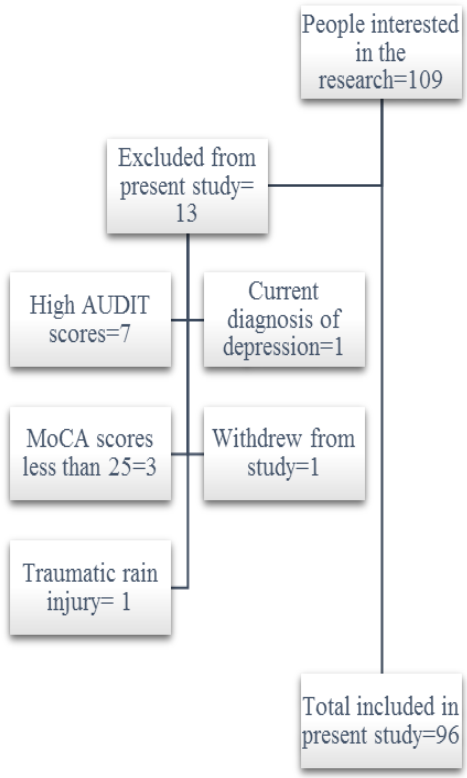

Figure 2. 3 Flow chart of total community recruitment

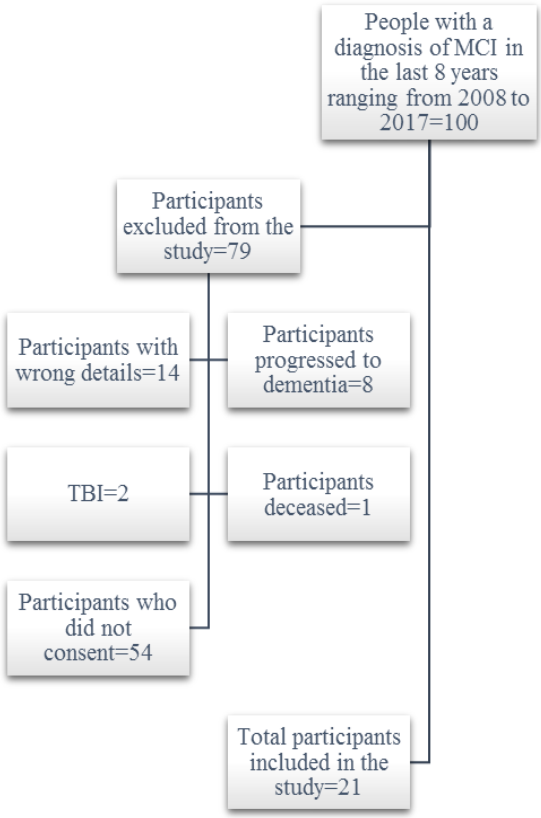

Figure 2. 4 Flow chart of clinical participant recruitment

Measures

All the participants completed measures described below. The assessments are broadly divided into demographic and background information, screening measures, test of social perception, neuropsychological assessments, social functioning measures and informant measures. The measures were selected based on measures used by other researchers and the availability of norms for the age group of this study.

Demographic and background information

A study-specific questionnaire was designed to collect demographic and additional information about the participants. The questionnaire requested information about demographics (date of birth, gender, marital status, ethnicity, handedness and education), health problems (hearing, sight and mobility, history of or a formal diagnosis of dementia, head injury, concussions, stroke, developmental disabilities, multiple sclerosis [MS], seizures/epilepsy and any other neurological/organic illness) as well as formal diagnosis of any mental health difficulties.

Participants were also asked to provide information about their relationship status (single/never been married, married, de facto, divorced or widowed), medications and driving status.

Screening measures

The eligibility measures assessed alcohol use, depression and overall cognitive function. The following are the measures used.

The Alcohol Use Disorder Identification Test (AUDIT) (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT is a widely-used screening tool to identify hazardous and excessive use of alcohol consumption, developed by the World Health Organization (WHO). It has been used in a range of populations (Allen, Litten, Fertig, & Babor, 1997; Allen, Reinert, & Volk, 2001). The AUDIT has been widely used in the older population across various cultures and languages, as a screening measure for alcohol abuse, as older adults are more vulnerable to the effects of alcohol as compared to a younger population, due to an increased risk of disease and possible interaction with medications (Aalto, Alho, Halme, & Seppä, 2011). The AUDIT has been widely used in the older population across various cultures and languages, as a screening measure for alcohol abuse (Chavez et al., 2016; Crome, Crome, Rao, & Crome, 2014; Nadkarni, Murthy, Crome, & Rao, 2013). The AUDIT was administered as an oral interview with the participants. The test takes about 10 minutes to complete and consists of 10 structured questions scored on a 0 to 4 ordinal scale. The items address alcohol consumption as well as the negative consequences experienced while drinking alcohol, including morning drinking, guilt following drinking, blackouts, alcohol related injuries and other people being concerned about drinking. Reliability coefficients range from 0.59 to 0.91(Shields & Caruso, 2003). Scores of 8 or more are considered as indicators of hazardous and harmful use of alcohol and an even higher score could indicate alcohol dependence. People who obtained a score over 8 were excluded from the current study.

The Geriatric Depression Scale–short form (GDS) (Sheikh & Yesavage, 1986); Yesavage et al. (1982). The GDS is a self-report tool that assesses depression in older adults. The GDS short form was developed in 1986 and consists of 15 items.

It has been used in community and inpatient clinical settings (D'Ath, Katona, Mullan, Evans, & Katona, 1994; Mitchell, Bird, Rizzo, & Meader, 2010). The GDS is answered dichotomously (yes/no) and questions people on their subjective depression experienced in the last week. A meta-analysis of 69 studies of the diagnostic validity of the GDS short form found 81.3% sensitivity and a 78.4% specificity, making it a "good" screening tool but a poor diagnostic tool (Mitchell et al., 2010). The GDS short form has robust reliability and validity. A validation study found a correlation of 0.84 with the long version of the GDS (Yesavage & Sheikh, 1986) and high internal consistency (Cronbach's alpha = 0.80) in a clinical population (D'Ath et al., 1994). Cronbach alpha coefficients in a cognitively intact general population depict acceptable internal consistency reliability of 0.75 (Friedman, Heisel, & Delavan, 2005). Scores above 5 are suggestive of depression and above 10 have a definite indication of depression. Depression may also show neuropsychological deficits in people; therefore, people above the score of 4 on the GDS were excluded in this study.

Montreal Cognitive Assessment (MoCA) (Nasreddine et al. (2005). The MoCA was developed in order to comprehensively screen major cognitive domains to detect early stages of impairment in neurodegenerative conditions such as Alzheimer's disease. The entire assessment takes about 10 minutes to complete. The MoCA is currently used in over 100 countries and is currently available in 46 languages and dialects, including five versions in Chinese (Chen et al., 2016). The MoCA has been widely used in studies with older adults (Del Brutto, Mera, Del Brutto, & Sedler, 2016; Julayanont et al., 2015; Kopecek et al., 2016; Larouche et al., 2016; Pendlebury, Klaus, Mather, de Brito, & Wharton, 2015; Suzuki et al., 2015; Sweet et al., 2011) in populations with dementia (Brown et al., 2016;

Gluhm et al., 2013; Van Steenoven et al., 2014) and MCI (Gagnon et al., 2010; Julayanont, Brousseau, Chertkow, Phillips, & Nasreddine, 2014; Mei et al., 2016). It has also been used in other populations, such as those with psychiatric conditions (Gierus et al., 2015; Wu, Dagg, & Molgat, 2014) and other neurological conditions such as stroke (Del Brutto et al., 2016), traumatic brain injury (De Guise et al., 2013) and epilepsy (Phabphal & Kanjanasatien, 2011). The MoCA has two alternate versions to enable retesting in clients. The MoCA consists of 22 items that assess visuospatial functioning, naming abilities, memory, attention, language, abstraction and orientation.

Internal consistency for the MoCA was good with a Cronbach alpha of 0.83 (Nasreddine et al., 2005). The MoCA showed good correlations with MMSE (r=0.66, p<.001) and with the Dementia Rating Scale (r=0.77, p<.001). The criterion validity for the cognitive domains were also well supported. Receiver operator characteristic (ROC) analysis helps analyse sensitivity and specificity of a test. The area under the receiving operating characteristic curve (AUC) for memory was 0.86, executive function was 0.79 and visuospatial function was 0.79 (Lam et al., 2013). Scores range from 0 to 30. One point is added to the final score for people who have had less than 12 years of education. Scores between 18 and 26 are suggestive of mild cognitive impairment, 10 to 17 of moderate cognitive impairment and scores less than 10 denote severe cognitive impairment. The MoCA showed 87% specificity in excluding cognitively normal older adults and high sensitivity (100%) and specificity (87%) to detect mild Alzheimer's disease (Nasreddine et al., 2005). Version one was used in this study. A cut-off score of 26 has shown 90% sensitivity of diagnosing MCI clients (Nasreddine et al., 2005), and hence it was used in this thesis.

The Awareness of Social Inference Test-Revised (TASIT); (McDonald et al., 2003a). The TASIT is an ecologically valid test (McDonald, Flanagan, Martin, & Saunders, 2004) designed to assess disorders in social cognition using real-life stimuli in the form of videoed vignettes of professional actors engaged in conversation. It is the first published test that uses video vignettes to assess subtleties in perception of emotion, sarcasm and lies.

The TASIT was initially developed for people with traumatic brain injury (Dimoska, McDonald, Pell, Tate, & James, 2010; McDonald et al., 2003a) but has also been used in adolescents (McDonald et al., 2015) and older people (Burdon et al., 2016; F. Kumfor et al., In press), and those with schizophrenia (Bratton et al., 2017; Gattoni et al., 2015; Kern et al., 2009; Rocca et al., 2016; Sparks et al., 2010), autism (Zimmerman, Ownsworth, Donovan, Roberts, & Gullo, 2016), eating disorders (Gramaglia et al., 2016), people with different types of dementia (Kumfor & Piguet, 2013; Rapp & Wild, 2011) including Alzheimer's disease (Henry et al., 2008) and frontotemporal dementia (Kipps et al., 2009; Kumfor et al., Rankin et al., 2009). Although developed in Australia, it has also been adapted and used in different cultures (Burdon et al., 2016; Westerhof-Evers, Visser-Keizer, McDonald, & Spikman, 2014).

The TASIT is comprised of three parts, assessing basic emotion recognition through to the ability to grasp aspects of communication. There are two forms available for the TASIT: form A and form B. Form A was used for this study. No significant differences were found between the form A and B (McDonald et al., 2003a). Part one of the TASIT assesses the person's ability to identify the six basic emotions–happiness, surprise, sadness, anger, revolt, anxiety and a neutral emotion. The recognition of happiness, surprise and neutral emotions are classified as positive emotions. Sadness, anger, anxiety and revolt are classified as negative

emotions. Twenty-eight scenes are presented on a screen displaying either one or two actors enacting a particular emotion. Each scene lasts from 15 to 60 seconds, and at the end of the scene, the participant is asked to point to the emotion from a stimulus card that best describes the emotion conveyed in that scene. The six basic and neutral emotions are presented in a random order on five different response cards. Their answer is noted on the record form. Each correct response receives one point. Each emotion has four video vignettes, each giving a maximum possible score of 28.

The complex or higher order social perception tests include the adequate recognition of sincere exchanges, simple sarcastic and paradoxical sarcastic exchanges, recognition of lying, sarcasm and the total scores for the social inference-minimal and social inference-enriched subtests of the TASIT. Part 2 and 3 of the TASIT tap into higher order social perception skills. Part 2 of the TASIT is called social inference-minimal (SI-M) and consists of 15 video vignettes lasting 20 to 60 seconds depicting conversations between two or more people. In five of these vignettes, the conversation is sincere. In the remaining 10 vignettes, exchanges are of a sarcastic nature, where the speaker means the opposite of what has been spoken.

Social inference-enriched (SI-E) is the third part of the TASIT. It consists of 16 video vignettes similar to SI-M lasting between 15 and 60 seconds. Eight of the scenes convey a message that is the opposite of what the main speaker believes; in other words, a lie. These are intended to deceive for the sake of diplomacy. The other half of the vignettes involve lies as well but with cues that indicate that the speaker aims to highlight the truth rather than minimise it.

At the end of each scene in SI-M and SI-E, the participant is asked to answer four questions with a “yes” or a “no.” For example, in one scene, Ruth is folding

clothes, while Gary reads a book and Ruth tries to pressurise Gary into helping her using sarcastic comments. The first question focuses on what the participant thinks the person is doing to the other person: "Is Ruth trying to pressure Gary into helping her?" The second question is what they think someone is trying to say to the other person, as in the message they are trying to get across. In this case "Is she trying to say it's OK if he doesn't help her?" The third question focuses on what they think someone is thinking or what their underlying belief is, which may be different from what they are saying–"Does she think he should stop what he is doing and help her?" Finally, the last question is what the participant thinks someone is feeling or what the emotion is that they feel or how they feel towards the other person or the situation. In the example, the question asked was "Is she annoyed with him?"

For each correct answer, a point is scored. Therefore, each vignette warrants a maximum possible score of four. SI-M generates total scores for sincere exchanges, simple and paradoxical sarcasm scores. The total score for the SI-M is the summation of sincere, simple and paradoxical sarcasm. The sum of scores of some of the items of SI-E is recorded as total lie scores and others are sarcasm scores. The total score for the SI-E is the sum of lies and sarcasm scores. For this thesis, the total scores of emotion recognition, sincere exchanges, simple sarcasm, paradoxical sarcasm, total of SI-M, lie score, sarcasm score and total of SI-E have been used.

The entire test takes about 45 to 60 minutes to complete, and the responses are scored using the TASIT manual. The manual provides norms for populations with traumatic brain injury, adolescents and more recently, older people (Mcdonald & Flanagan, 2017). The TASIT was designed to be a criterion referenced test and, therefore, has strong ceiling effects and low variability for social perception within the normal range (McDonald et al., 2003a). The ecological validity of the TASIT

has been established. McDonald et al. (2004) videotaped 21 participants with TBI having a spontaneous conversation with a partner. This was rated using a Behavioural Referenced Rating System of Intermediate Social Skills-Revised (BRISS-R) (Wallander, Conger, & C. Conger, 1985). The TASIT correlated with spontaneous social behaviour, showing high levels of ecological validity. The TASIT was chosen for this study because it is a more ecologically valid test that measures social perception by taking into consideration verbal and nonverbal aspects of communication such as tone of voice, contextual information and body language.

Neuropsychological functioning

Studies of cognition in ageing, MCI and dementia show difficulties across multiple domains of cognition (Collie, Maruff, & Currie, 2002; Perri et al., 2005; Rolstad et al., 2009; Simon, Yokomizo, & Bottino, 2012; Underwood et al., 2017). The cognitive domains assessed in this study were selected based on previous research. They include memory, language, executive functioning and visuospatial abilities. After completing the assessments with the community participants, a principal components factor analysis was performed using the raw scores from the cognitive assessment to see if if the test loaded on the prespecified cognitive Eighteen of the tests used as a part of the cognitive assessment were subjected to principal axis factoring to assess the dimensionality of the data. The Kaiser-Meyer-Olkin was 0.793 which is well above the recommended threshold of 0.6 and the Bartlett's Test of Sphericity reached statistical significance indicating the correlations were sufficiently large for exploratory factor analysis. The number of factors was decided based on eigenvalues and inspection of the scree plot. These components or factors were then rotated using a varimax

orthogonal rotation and interpreted by considering only those variables with a factor loading magnitude of 0.40 or greater. These factors were used to determine which test loaded on each cognitive domain. Table 2 summarises the five factors that were extracted.

Attention is a difficult domain to define as this neuropsychological skill is a required for any of the tests. Hence, the tests that loaded on the 'attention' domain were allocated to the cognitive domains described in each test manual. Colour naming and word reading tests that loaded on Attention were allocated to the language domain, and the color word interference was moved to executive functioning domain. Further, the GMCT which loaded on the executive functioning domain was placed under the visuospatial domain as it was more appropriate. The final tests and their corresponding domains are illustrated in Table 2. Each of these tests are explained in more detail in the measures section below.

Table 2. Factor and factor loadings[a] from principal components factor analysis using 18 raw scores of neuropsychological measures[b]

Cognitive Measure	Factor 1: Visuospatial	Factor 2: Attention	Factor 3: Memory	Factor 4: Language	Factor 5: Executive Functioning
Letter fluency (DKEFS)	-.135	-.160	-.103	**-.702**	.090
Category Fluency (DKEFS)	.150	-.116	.023	**-.817**	-.241
Category Switching (DKEFS	.123	-.166	.203	**-.510**	.099
Logical memory	.295	.010	**.484**	.132	.117
ISRL	.168	-.189	**.571**	-.087	.062
OCL	.188	.165	**.718**	-.108	-.417
ONB	-.334	.282	**.582**	-.390	.219
TWOB	-.109	-.317	**.747**	.104	.211
Color Naming	.111	**-.784**	-.048	-.161	-.117
Word reading	-.081	**-.873**	.001	-.010	-.025
Color word interference	.030	**-.697**	.224	-.126	.065
Number sequencing trial making	.385	.177	.043	-.331	**.487**
Color word inhibition switching	.227	-.384	-.008	-.211	**.452**
GMCT	.078	.047	.085	.092	**.852**
Visual scanning Trials	**.674**	-.231	-.106	-.179	.101
Letter sequencing Trials	**.621**	.051	.023	-.184	.383
Number letter sequencing	**.500**	.039	.114	-.371	.261
ROCFT	**.741**	-.008	.157	.135	-.072

[a]Factor loadings represent the correlation between the individual variable and each factor (after rotation); bold font and shading indicates magnitude of factor loadings above 0.40
[b]PCFA was implemented on the raw scores of neuropsychological measures.
Abbreviation: DKEFS, Delis Kaplan Executive System; WMS, Wechsler Memory Scale; ISRL, International Shopping List Test; OCL, One Card Learning; ONB, One Back Test; TWOB, Two Back Test; GMCT, Gordon Maze Chase Test; ROCFT, Rey Osterrieth Complex Figure Test

The CogState Research Test Battery (www.cogstate.com) is a reliable and valid computerised touch screen assessment of cognitive function including psychomotor performance, attention, memory, and executive functioning. The CogState consists of a number of individual tasks, which can be put together to form a test battery. All of the subtests are designed for repeated administration with minimal learning effects. The CogState has been used widely in aging studies (Harrington et al., 2017), Alzheimer's disease (Snyder et al., 2016), frontotemporal dementia, cognitive impairment in older people due to HIV (Bloch et al., 2016; Underwood et al., 2017) as well as in the measurement of cognitive dysfunction in issues such as depression (Davis et al., 2017), schizophrenia (Benoit, Harvey, Bherer, & Lepage, 2016), and medical conditions (Kok, Koerts, Tucha, Scheeren, & Absalom, 2017; Sands et al., 2017). The CogState has also been used successfully in the screening and assessment of people with MCI (Lim et al., 2015). For the purposes of this study, five subtests were used, which took approximately 20 minutes to complete. They were presented on a computer and followed the same order of presentation. The test started with the International Shopping List Test (memory domain), the chase task (visuospatial functioning domain), one back test (memory domain), two back test (memory domain) and ended with the delayed recall of the International Shopping List Test (memory domain).

All raw test scores of the five tests used were log-transformed or arcsine root-transformed according to the CogState manual guidelines. Norms in the manual ranged from 15 to 90 years of age.

International Shopping List Test. This subtest assesses verbal learning and memory using a word list-learning paradigm. Shopping list tests have been

commonly used due to their sensitivity of detecting mild verbal learning and verbal memory issues (Thompson et al., 2011). During the test, the researcher reads out a list of words of shopping items as they appear on the screen of the computer. The participant was then asked to recall as many items as they can remember from the list. The same list is presented to the participant three times and then after a delay. The total number of correct responses made in remembering the list after a delay is recorded. This test takes about five minutes to complete. The total number of words recalled over three trials were recorded and the higher the score, the better the performance. The total number of correct items recalled after the delay was used in this study.

Chase Task. This subtest uses a stylus to chase a target as it moves through a grid on the screen. This test assesses reaction time and attention span. The test begins after a practice with no time limit. The primary outcome for this test is moves per second. Lower scores indicate better performance.

One Card learning. The one card learning test assessed visual memory using a pattern separation paradigm. A playing card appeared in the centre of the screen and the participant had to indicate if they had seen the card before in this test. They had to make a decision as quickly as possibly by indicating yes (right click on the mouse) or no (left click on the mouse). The test began after a short, timed practice to ensure the participant understood the task. The accuracy of response was the primary outcome of this test (the arcsine transformation of the square root of the proportion of correct responses). Higher scores indicate better performance.

One Back Task. The one back test assessed working memory and attention using an n-back paradigm. A playing card appeared in the centre of the screen and the participant had to decide if the card was the same as the one shown just before. The participant had to work as quickly as possible using the mouse in the same way as in the one card learning test. The speed and accuracy of performance was generated for scoring. The reaction time was used as the measure of performance in this study. Lower scores on speed indicated better performance.

Two Back Task. The two back test also assesses working memory and attention. The test is similar to the one back test but the participant had to decide if the card was the same as the one shown before the previous card or two cards back. The reaction time was generated for scoring. Low scores on speed indicated better performance.

The Delis-Kaplan Executive Function System (D-KEFS); (Delis, Kaplan, & Kramer, 2001). The D-KEFS is a well validated measure consisting of nine subtests designed to assess a variety of verbal and nonverbal aspects of executive functioning, including concept formation, inhibition, flexibility of thinking and problem solving. It has been designed to be used in a flexible manner, using selected subtests to suit the specific research question or a client's presenting problem (Delis, E. Kaplan, & Kramer, 2001). Each subtest is presented in an interactive game-style way.

The D-KEFS was standardised on a stratified sample of 1750 healthy participants aged from 8 to 89 years of age. The D-KEFS showed a moderate to high split-half reliability for its subtests. For example, the letter fluency condition was .68-.90, the colour-word interference test was .62 to .86 Delis et al., 2001).

The D-KEFS is a well validated test. There were good inter-correlations between subtest as well as with similar cognitive tests. Moderate correlations were found between the DKEFS California Card Sorting Test (CCST) and the Wisconsin Card Sorting Test (WCST). The D-KEFS also show reasonable sensitivity in distinguishing between different clinical groups, including schizophrenia, foetal alcohol syndrome and chronic alcoholism. The D-KEFS was also found to be an ecologically valid test. The trail making, design fluency, verbal fluency and the tower tests from the D-KEFS were administered to older adults between the ages of 65 and 92. These measures accounted for approximately 26% of the variance in observed functional ability (r=.66) (Mitchell & Miller, 2008).

Not only has the D-KEFS been used in cognitive studies in the older population (Berg, Swan, Banks, & Miller, 2016; Jefferson, Poppas, Paul, & Cohen, 2007; Mowszowski, Lampit, Walton, & Naismith, 2016), it has also been used in MCI (Delprado et al., 2012; Jefferson et al., 2006; Lindbergh et al., 2016), dementia (Gansler, Huey, Pan, Wasserman, & Grafman, 2017), traumatic head injuries (Cook, Katzenstein, McDonald, & Highley, 2014; Mayfield, Reyes, Mayfield, & Allen, 2014), frontal lobe lesions (Keifer & Tranel, 2013), stroke (Wolf, Stift, Connor, & Baum, 2010, Wolf & Rognstad, 2013), multiple sclerosis (Parmenter et al., 2007; Weinstock-Guttman et al., 2011) and psychiatric disorders like schizophrenia (Muñoz Negro, Ibáñez Casas, Ballesteros Ramos, Busaileh Salas, & Cervilla Ballesteros, 2013; Ryder, Lambert, & Blaszczynski, 2010). For the purposes of this study, three subtests (colour word interference, verbal fluency and trial making test) were used, which took approximately 15–20 minutes to complete. Scoring was carried out according to the manual's instructions. All the raw scores were converted to scaled scores (M=10 and SD=3) according to the manual. Higher scores indicate better performance. Each subtest

of the D-KEFS generates primary and optional scores, which are sometimes called the contrast scores. Further, error scores are also generated. For the purposes of this thesis, the primary scaled scores were used.

Colour Word Interference Test. There are four conditions in the subtest that assesses cognitive flexibility, and it is based on the classic Stroop test (Stroop, 1935). The entire subtest was administered using standardised instructions. In the first condition, the participant was required to name the blocks of colours in the test. In the second condition, they were asked to read out words of the colours. In the third condition, the participant was asked to inhibit reading coloured words while naming the colour. In the fourth condition, the participant was asked to switch between naming the colour and reading the conflicting word. The time taken and the errors made were recorded. The manual was used to record the scaled score

Trail Making Test. There are three conditions in this subtest assessing visual scanning and attention, flexibility of thinking and working memory. In the first condition, participants strike out the number 3 as quickly as they can. In the second condition, participants draw a line from one number to another in numerical order. In the third condition, participants alternate connecting letters and numbers in numerical and alphabetical order. The total time taken to complete each condition was recorded in the summary sheet, and, once again, this was converted to the scaled score, which was used in this study.

Verbal Fluency Test. There are three conditions to this subtest assessing letter fluency, category fluency and category switching. In the first condition,

participants are required to generate as many words as they can within a minute that begin with a certain letter (F, A and S). The number of correct responses were recorded and converted into scaled scores which was used in this study. In the second condition, participants are required to generate as many words that belong to a semantic category (animals and boy's names). The correct number of responses which were converted to scaled scores for the first two subtests were used in this study. In the third condition, the participants are required to alternate between two semantic categories (fruits and furniture) for a minute. The total correct number of switching responses were recorded and converted to the scaled scores. This was then used for this study.

Logical Memory I of the Wechsler Memory Scale (WMS) (Wechsler, 1987). The WMS is a neuropsychological measure designed to measure different memory functions. The logical memory subtest of the WMS is a widely-used test in screening cognitively healthy older adults from people with MCI or mild dementia (Gavett et al., 2016; Gavett et al., 2009; Rabin et al., 2009; Sei, Christine, Kristine, Irena Stijacic, & Deborah, 2007). It is one of the standard tests used in the assessment of people with MCI, for instance in the Alzheimer's Disease Neuroimaging Initiative (ADNI), one of the largest studies of MCI progression (Petersen et al., 2010). It has also been used in other populations such as dementia (Chapman et al., 2016).

Memory tests based on prose or stories have shown ecological validity in assessing people with memory complaints. The participant is asked to listen to two different stories and is then asked to immediately recall the story just heard. Story A and story B were both presented verbally. A shorter story is used for older adults (Holdnack, Drozdick, Weiss, & Iverson, 2013). Therefore, adults over the age of

69 are administered the shorter story. Each correct part shown on the recording form for each story recalled is given a score of one. This is then summed and converted to a scaled score according to the manual, which was used in this study.

The Rey Osterrieth Complex Figure Drawing Test (ROCFT) (Osterrieth, 1944; Rey, 1941). The ROCFT is a test used to assess visuospatial and constructional abilities. The complex drawing was presented to the participant and they were asked to copy the drawing to the best of their ability in their own time. The ROCFT has been widely used in MCI studies (Gu et al., 2017; Horr, Messinger-Rapport, & Pillai, 2015; Marková, Laczó, Andel, Hort, & Vlček, 2015; Tsolaki et al., 2011; Zhou & Jia, 2009) as well as in cognitively healthy older adults (Jabourian et al., 2014). The copy test alone was used in this study. This test takes about 2 minutes to administer. For the copying task, the inter-rater reliability is reported to be r=0.96 ($p<0.0001$) (Caffarra, Vezzadini, Dieci, Zonato, & Venneri, 2002). The entire drawing is broken down into 18 units and scored according to the manual. Points of 0 to 2 are assigned to each of the 18 units depending on the exactness and the placement of the drawing. The raw scores are then converted to T scores as elaborated in the manual (Meyers & Meyers, 1995). Possible scores range from 0 to 36.

Social Functioning Measures

The participants completed these measures in order to supplement information regarding their social activities.

The Social Activity Log (SAL); (Syrjala, Stover, Yi, Artherholt, & Abrams, 2010b). The SAL assesses the frequency and variety of social activities outside of

everyday responsibilities. The SAL has been used largely in cancer settings (Syrjala, Stover, Yi, Artherholt, & Abrams, 2010a). It has 15 items and questions focus on the frequency of various activities like shopping, social events and interaction with friends and family in a typical month of the person's life. The three subscales of the SAL are non-contact events (receiving and sending emails, talking on the telephone), regular events (participating in sports/games, coffee, tea, other drinks, visits to homes and from others) and special events (social events, concerts, theatre, museums, art exhibits, etc.). This assessment takes around 10 minutes to complete and was used as an adjunct to the background information collected. The SAL has good internal consistency, Cronbach α of 0.82 (Syrjala et al., 2010a). A higher total score means an increased frequency of social activities in the person's life. For the purposes of this study, the total scores for the three subscales and the total score was used.

The Lubben Social Network Scale (LSNS-6); (Lubben et al., 2006). The LSNS was specifically devised to address the social network of the older population (Gabrielson & Holston, 2014; Gabrielson, Holston, & Dyck, 2014; James Lubben, Blozik, Gillmann, & Iliffe, 2006; Vilar-Compte, Vargas-Bustamante, & Lubben, 2018) and is also sometimes used to identify social isolation in older adults (Lubben & Gironda, 2003a). It consists of six items that measure quantity, emotional closeness and frequency of contact with family and friends.

It has a good internal consistency of 0.74 (Gabrielson & Holston, 2014) and 0.78 to 0.90 in older adult population (Wells, 2010). It is scored on a scale of 0 to 5, with total scores ranging from 0 to 30. In the present study, the items were totalled to produce a total score. A higher score in a particular subscale indicates a higher

perceived level of social support. Total scores for social network with friends and family, as well as the overall total score was used in this study.

Informant Measures

Subjective cognitive complaints from people may or may not be related to actual changes in cognition. Information about cognitive change secured from an informant is an important part of the assessment. Information about the participant's premorbid and current level of independence was determined using the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) and the Lawton's Instrumental Activities of Daily Living (IADLS).

The Lawton Instrumental Activities of Daily Living Scale (IADLS; Lawton & Brody, 1969). The IADLS was developed to assess the more complex activities of daily living required to function in the community. These include cooking, shopping, managing finances, ability to use the telephone, laundry, housekeeping and managing own medications. The test consists of 8 items that take around 10 to 15 minutes to administer and provides a resulting score of low function (0) to high function (8). It can be administered face to face or as a self-report questionnaire and is completed by people who know the participants well. It has been used widely in general populations as well as clinical settings with older people (Alosco et al., 2014; Ferrell, Josephson, Norvid, & Alcorn, 2000; Graf, 2008; Hilgenkamp, van Wijck, & Evenhuis, 2011; Wallace & Shelkey, 2008). There was a high level of internal consistency (.93) in participants who were in the early stages of dementia (Farias, Harrell, Neumann, & Houtz, 2003). A one month test-retest reliability of the IADLS was also high (>.90) in people who had a probable Alzheimer's disease (Green, Mohs, Schmeidler, Aryan, & Davis, 1993). The

IADLS showed moderate to high correlations with other measures that assess activities of daily living. For instance, in their assessments with older people Lawton and Brody (1969) found correlations of .61 with physical self-maintenance, .48 with mental status examinations and .36 with behaviour and adjustment. Further, there was a moderate (.66) correlation between the IADLS and the Direct Assessment of Functional Status (DAFS) (Farias et al., 2003). In this study, a total score is calculated at the end of the assessment with the maximum score being 8 and the minimum is 0. Higher scores indicate a greater functional ability.

The Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm, 1996). The IQCODE was used in this study to measure cognitive decline from a premorbid level of functioning. It is a 26-item assessment tool that rates change over the previous 10 years in memory and everyday tasks and takes about 15 minutes to administer. Informants are required to rate each statement on a five-point scale:1 is much improved and 5 is much worse. It is a widely-used instrument in older population settings and has been used as a screening tool to detect dementia (Harrison et al., 2014) and MCI (Li, Jia, & Jia, 2012). The IQCODE consists of long and short forms. The long form has been used in this study. It consists of 26 items that address everyday memory and function, including short-term and long-term memory, financial awareness, learning, orientation in time and space, and executive skills. The IQCODE is a valid test and has been used as a screening tool in dementia and has shown a moderate correlation (0.65) with a test of episodic memory performance (Jorm, 2009). Reliability studies that cover a range of populations, languages and cultures have shown high coefficient alpha that range between .93 to .97 (De Jonghe, 1997; Fuh

et al., 1995; Morales, Bermejo, Romero, & Del - Ser, 1997). The IQCODE has been correlated with a few cognitive screening tests, especially the MMSE (between -.37 and -.78) (Helen Christensen & Jorm, 1992; Jorm & Jacomb, 1989) and the Abbreviated Mental Test Score (between -.54 and -.62) (Flicker, Logiudice, Carlin, & Ames, 1997; Thomas et al., 1994). The correlations are stronger when used in people with a diagnosis of dementia as compared with cognitively healthy ones. For example, Helen Christensen and Jorm (1992) found that the correlation between MMSE and the IQCODE was -.37 in healthy academics and scientists. In comparison, older participants (mean age 83) living in a residential facility showed correlations of -.78 between the MMSE and the IQCODE (Jorm & Jacomb, 1989). The IQCODE had high (-.65) correlations with episodic memory, -.42 (Jorm et al., 1996) with the WMS Logical Memory (Jorm et al., 1996) and .34 with the Auditory Verbal Learning Test (Starr, Nicolson, Anderson, Dennis, & Deary, 2000).

The IQCODE is scored by adding up the scores for all questions, and dividing this by the number of total questions (i.e., a mean score is calculated). Different cut-offs have been suggested to classify participants as having significant decline amounting to a probable diagnosis of dementia. Scores between 3.3 and 3.6 are suggestive of significant cognitive decline. For the purposes of this study, the mean score was used.

Table 3. Description of neuropsychological domains, the tests used to assess each domain and the outcome scores

Information	Name of Test	What does it measure	Outcome Scores
Screening Tests	Montreal Cognitive Assessment (MoCA)	Cognitive screening	Total score
	Alcohol Use Disorder Identification Test (AUDIT)	Alcohol use and disuse screening	Total score
	Geriatric Depression Scale (GDS)	Depression screening in older people	Total score
Social perception	The Awareness of Social Inference Test (TASIT)	Emotion recognition, recognition of lies, sarcasm and humour	Total score
	Neuropsychological Measures		
Memory	Logical memory I (WMS)	Narrative memory	Total number of words recalled
	One back test (Cogstate)	Working memory and attention	Average reaction time for correct responses*
	Two back test (Cogstate)	Working memory and attention	Average reaction time for correct responses*
	One card learning (Cogstate)	Visual memory	Accuracy of response
	International Shopping List Recall (Cogstate)	Verbal learning and memory	Total number of words remembered
Language	Letter fluency (DKEFS)	Verbal fluency	Response accuracy
	Category fluency (D-KEFS)	Verbal fluency	Response accuracy
	Category switching (D-KEFS)	Verbal fluency	Response accuracy
	Colour naming (D-KEFS)	Language	Response accuracy
	Word reading (D-KEFS)	Reading ability	Response accuracy
Executive functioning	Number sequencing (D-KEFS)	Number sequencing	Completion time
	Letter sequencing (D-KEFS)	Letter sequencing	Completion time
	Number-letter sequencing (D-KEFS)	Cognitive flexibility	Completion time
	Colour-word interference (D-KEFS)	Cognitive flexibility	Completion time
	Colour-word interference switching (D-KEFS)	Cognitive flexibility	Completion time

Visuospatial Functioning	Rey Osterreith Complex Figure Drawing Test, Copy	Visual and constructional abilities	Total score
	Chase task (Cogstate)	Attention and reaction time	Average reaction time for correct responses*
	Visual scanning (D-KEFS)	Visual scanning and attention	Completion time
Social Functioning Measures	Social Activity Log (SAL)	Social activity	Total score
	Lubben's Social Network Scale	Quantity, emotional closeness and frequency of contact with family and friends.	Total score
Informant Measures	Lawton's Instrumental Activities of Daily Living (IADLS)	Ability to perform complex daily activities	Total score
	Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)	Informant's view of cognitive decline from premorbid level of functioning	Mean score

Note. * Low scores indicate better performance, WMS= Wechsler's Memory Scale-Fourth Edition, D-KEFS=Delis-Kaplan Executive Function System

Procedure

Potential participants either responded to the advertisements or were contacted by phone after they had received a letter about the study. Over the phone, the potential participants were briefed about the study and were encouraged to ask any questions regarding the study. Once consent was obtained, a mutually convenient date, time and place was arranged to meet with those who were interested in taking part in the study. The venue for the assessment was either an office at the University of Waikato, the participant's house or place of work. If the assessment occurred at the participant's house or office, the assessment was carried out in a quiet room and the examiner and participant sat at a table with minimal distractions. The information regarding the study was provided to the participant along with an information sheet (see Appendix C) and both consent and confidentiality was also explained. Each participant signed a consent form (see Appendix C). Each participant went through the screening process. Those who failed to meet the inclusion criteria were thanked for their time and those with high scores on the AUDIT and GDS were encouraged to meet with their GP for further management.

The entire assessment took between 3 to 4 hours, depending on the number and length of breaks. The testing was carried out either on the same day or on two or three separate days within a month of the first assessment. The order of test administration is described below in Figure _. At the end of the assessment, the participants from the community sample received a $15 coffee voucher and the DHB participants received a $30 supermarket voucher to thank them for their participation. Participants were asked if they would like a summary of the results.

The community sample were offered a summary of the overall results and findings, whereas the DHB sample were also offered a summary of their individual results sent to them and/or their GP.

During this first meeting, eligible participants were also asked if there was a close friend/family of the participant who had known the participant for 10 or more years and were preferably living with them or spent considerable time with them who would be able to complete a series of informant measures. The informants were either met separately or were sent the questionnaires with a self-addressed envelope to be completed and returned to the researcher. If they opted to post the questionnaires back, they were contacted over the telephone, where they were given information regarding the study as well as answering any questions they had regarding the questionnaires,

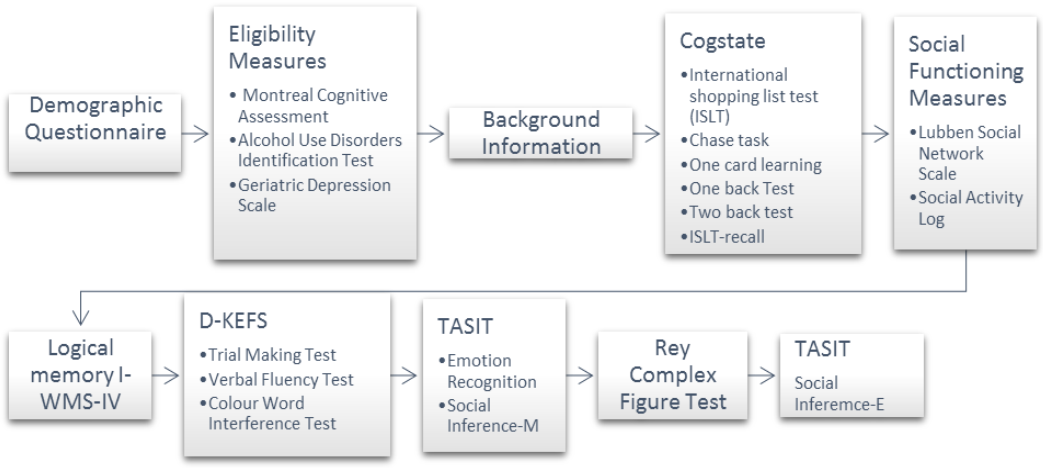

Figure 2. 5 Order of assessments

Statistical Analysis

Data were entered into the Statistical Package for the Social Sciences (SPSS version 23) and checked for missing data. Normality for the data was also checked

by examining histograms and pp plots as well as carrying out the required normality statistic.

In order to interpret the neuropsychological data collected and to be able to carry out further analysis, the test scores were transformed to *T* scores, with a mean of 50 and a standard deviation of 10. If the scores were in the opposite direction (i.e., lower scores meant better performance), the *z* score sign was reversed. This was carried out using the following steps for each test.

1. The mean of the participant's age-appropriate reference group from the normative sample was subtracted from the raw score of each test.
2. The result of this was divided by the standard deviation of the participant's age-appropriate reference group, resulting in a *z* score for each test score for each participant.
3. This was then multiplied by 10 (the arbitrary standard deviation used for *T* scores).
4. Lastly, the result of this was added to 50, which is the arbitrary mean used for *T* scores.

Finally, the domain scores were calculated by averaging the mean T score with the number of tests in the domain. This resulted in four separate domain scores (memory, language, executive functioning and visuospatial functioning) for each participant.

In the current study, the analysis was conducted in four parts. In order to address the main research question regarding social perception in MCI, it was first necessary to decide on the most appropriate classification criteria for MCI. Therefore, the first part of the analysis focuses on identifying the most appropriate criteria to use to classify MCI for the subsequent analyses. These criteria were based on classification systems outlined in previous chapters (Jak et al., 2009). The difference between the classification systems is based on the cut-offs of the number of standard deviations below the normative mean (1 or 1.5 SD) and the

number of tests within the domain that reached the relevant cut-offs (at least one or at least two tests). This includes the liberal method, the comprehensive method, the conventional method and the conservative method. The four classification systems were used in order to examine how the DHB participants were classified. The classification system that was used at the DHB was the one that most closely approximated current clinical practice and was thus used as a "gold standard" diagnostic system to identify MCI in the community recruited participants. This classification of participants into "MCI" and "non-MCI" was then used for the rest of the analyses.

To determine if MCI was associated with social perception difficulties, a series of between-groups analyses were conducted to compare the MCI and non MCI groups' performance on the TASIT. Cohens statistic was used to determine effect size, where scores at or below .2 were considered having low effect size, .5 was medium effect size and .8 and above depicted large effect size. The normative data for older adults on the TASIT was also used to identify people who showed moderate deficits and scored at least 1.5 SD below mean. This was then used to compare the proportion of those with and without MCI who met the cut-offs.

To explore the association between social perception and neuropsychological functioning, participants' performance in each domain was correlated with the TASIT variables. Correlational analyses were also used to examine the relationship between the recognition of lower and higher order social perception skills.

Lastly, participants with and without MCI were compared in social functioning and informant measures using between-groups analysis.

Chapter 3-Results

In order to answer the main question of this research regarding social perception deficits in mild cognitive impairment, the first step was to classify participants with MCI. The first section of the results describes the classification of MCI, followed by addressing the main questions of this thesis: the relationship between social perception, MCI and performance on neuropsychological tests. The next section focusses on using the TASIT norms to identify participants who have deficits on the subtests. The last section compares the social and informant measures between participants who show deficits on the TASIT subtests.

Before beginning the analysis, the data were screened for missing values and normality. One participant did not complete the social inference-minimal and the social inference-enriched subtest, as he complained of not being able to hear the TASIT subtest. This was carried out using P-P plots and histograms. P-P plots or probability-probability plots graphically display the "cumulative probability of a variable against the cumulative probability of a particular distribution" (Field, 2013, p.179). Histograms of neuropsychological domains, TASIT variables, social measures and informant measures were plotted and inspected. Further, the Kolmogorov-Smirnov (KS) test was conducted in order to determine whether the main variables of the neuropsychological domains and the TASIT were normally distributed. Results for the histograms and the KS test for memory domain (D (117) = .075, p = .15), language domain (D (117) = .064, p = 0.200), executive functioning domain (D (117) = .146, p = <.001), visuospatial functioning domain (D (117) = .079, p = .070), emotion recognition (D (116) = .135, p = <.001), social inference-minimal test (D (116) = .124, p = <.001) and the social inference-enriched test (D (116) = .167, p = <.001) were significant, indicating

that the scores on the neuropsychological domains were normally distributed, and the TASIT were not normally distributed. Additionally, results of the histograms and KS statistic for Social Activity Scale (D (74) = .074, p = 0.200), Lubben's Social Network Scale (D (74) = .497, p = <.001), the Instrumental Activities of Daily Living Scale (D (74) = .211, p =<.001) and the Informant Questionnaire on Cognitive Decline in the Elderly (D (74) = .104, p = .05) were not normally distributed.

Part 1: Classification of participants

Once all the scores were converted and placed on a common metric, the descriptive statistics for each of these tests were calculated for the community and the DHB recruited sample (see Appendix J).

The participants from both samples (n=117) were then classified according to the four diagnostic criteria described earlier (see page 102 methods); the descriptive statistics of demographic variables, screening measures and neuropsychological domains are presented in Appendix M. This table shows the mean performance of the groups on the screening measures as well as the domain scores according to each of the classification systems.

The prevalence of participants meeting criteria for MCI varied widely between classificatory systems used. As can be seen in Appendix M, 12.8 % to 84.6 % of participants were classified as having MCI, depending on the system used. With the liberal criteria, more than three-quarters of the participants had a formal diagnosis of MCI, whilst only a third of the participants met the stricter criteria, being the conservative method. As expected, participants in the conservative group had the worst performance across all the domains of neuropsychological functioning, whereas performance on neuropsychological domains was higher when the liberal method was used.

The number of participants classified as having MCI according to the four different criteria were then examined. Table 3.1 shows the number and percentages of participants meeting the different criteria of MCI, presented separately for the DHB recruited participants and the community sample.

Table 3. 1 Number and percentages of participants meeting the criteria for MCI according to four methods.

	DHB-diagnosed (21)	**Community (96)**
Liberal Criteria *(1 SD below mean on any one measure of a domain)*	21 (100%)	78 (81.3%)
Conventional Criteria/Peterson's criteria *(1.5 SD below mean on at least one measure in two domains)*	21 (100%)	47 (48.9%)
Comprehensive Criteria *(1 SD below mean on two or more measures of a domain)*	16 (76.2%)	25 (26.04%)
Conservative Criteria *(1.5 SD below mean on two or more measures of a domain)*	10 (47.6%)	5 (5.2%)

Note. DHB = District Health Board; MCI = Mild Cognitive Impairment; SD = standard deviation

There are no commonly agreed objective criteria for diagnosing MCI. The formal diagnosis used by the DHB was the "gold standard" for deciding on the classificatory system used, due to the unavailability of other useful standards such as longitudinal studies, information from family members and biomarkers. In order to decide which the most appropriate criteria for the use was in the present study, classification using the criteria was conducted separately for the DHB group, all of whom had been independently clinically assessed and diagnosed with MCI. Visual inspection of Table 3.1 shows that all participants who were diagnosed with MCI at the DHB met the criteria of MCI according to the liberal and the conventional method. Deciding between the liberal method and the conventional method was then based on level of impairment and prevalence rates of MCI in the community. The chance of false positives is high in the liberal method due to the lower (1 SD) levels of impairment. A majority of normal participants in neuropsychological studies have lower scores on one test without warranting an abnormal label (Jak et al., 2009). In addition, the prevalence rates of MCI in the community has been reported to be within the ranges of 4.5% and

26.7% from the age of 60 to 89 (Sachdev et al., 2015). The liberal criteria diagnosed 81.3 % of community participants with MCI, which is much higher than the prevalence studies. The conventional criteria classified 48.9 % of participants from the community as meeting the criteria for MCI. Based on these findings, the conventional method was chosen as the most suitable method to classify participants as meeting criteria for MCI or not.

Based on this, two new groups were formed that included anyone (regardless of recruitment from DHBs or community) who met the conventional criteria (MCI group) and all the others (non-MCI group). From here onwards, the MCI group, according to the conventional criteria, will be referred to as the MCI Conv group. The group that did not meet the criteria according to the conventional method was labelled non-MCI. The demographic and mean scores on the screening measures and the neuropsychological domains for these two groups are presented in Table 3.2

Table 3. 2 Descriptive and inferential statistics of performance on the neuropsychological measures in people with and without the diagnosis of MCI according to the conventional criteria

Demographic details	**MCI-Conventional (n= 68)**		**Non-MCI (n= 49)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*
Age	66.22 (9.69)	46-88	61.98 (8.14)*	50-88
Gender	F = 67.6%		F = 67.3%	
Education (y)	12.33 (3.18)	0-17	12.94 (3.36)	0-17
MoCA	27.10 (3.21)	14-30	29.04 (1.15) *	26-30
GDS	1.32 (1.39)	0-7	.86 (1.08)	0-4
AUDIT	2.51 (1.9)	0-8	2.96 (1.94)	0-8
Memory Domain	49.24 (4.89)	32.05-59.87	51.47 (3.04) *	41.96-56.66
Language Domain	54.61 (9.13)	24-70.67	59.67 (6.26) *	46.67-74
Executive Functioning Domain	52.25 (9.09)	20-65.33	58.19 (4.4) *	46-66.67
Visuospatial Domain	46.78 (5.81)	29.10-57.02	51.25 (3.84) *	43.20-58.1

Note. SD = standard deviation; MCI = mild cognitive impairment; MoCA = Montreal Cognitive Assessment; GDS = Geriatric Depression Scale; AUDIT = Alcohol Use Disorders Identification Test; DKEFS = Delis Kaplan Executive Function System; ROCFT = Rey Osterrieth Complex Figure Test

* $p<0.05$ all p values based on t-test comparisons between MCI-Conventional and non-MCI groups

As can be seen in Table 3.2, the MCI Conv group obtained lower scores than the non-MCI group on all the neuropsychological domains. Further, the participants in the MCI Conv group were older and, on average, had lower MoCA scores. A series of independent t-tests confirmed that these differences were statistically significant.

Participants in the non-MCI group were younger than those in the MCI group (t (115) = -2.49, p = .014, d = .47). The scores on the MoCA were significantly lower in the MCI Conv group (t (89.24) = 4.59, p = <.001 d = .80), possibly because the MCI Conv group included all the DHB recruited participants where the cut-offs for eligibility for the study on the MoCA were not applied. The participants who were in the MCI Conv group were not significantly different on their depression scores compared to the non-MCI group (t (115) = -1.952, p = .053, d = .37). Similar results were found with the AUDIT scores. People in both the MCI Conv and Non-MCI groups were below the cut-off for alcohol abuse and there were no significant differences between the two groups (t (115) = 1.25, p = .213, d = .23). Additionally, there was not a significant difference in education between the two groups (t (115) = 0.996, p = .321, d = .019).

The average T scores for the neuropsychological domains between the two groups were significantly different. This was not surprising, given performance on the neuropsychological tests were the main criteria for classification. Participants in the MCI Conv group performed significantly worse on all four neuropsychological domains–memory (t (112.8) = 3.03, p = .003, d = .55), language (t (114.75) = 3.56, p = <.001, d = 0.65), executive functioning (t (102.3) = 4.68, p = <.001, d = 0.83) and visuospatial functioning (t (114.22) = 5.002, p = <.001, d = .91). The effect sizes for all the domains ranged from moderate to high. It is worth noting that the means of the MCI Conv group, although lower than the

non-MCI group, were still in the normal range. The lowest scores were on the visuospatial domain, which was only slightly below the normal range for the T scores.

Determining subtypes of MCI

The classification of MCI also enables categorising subtypes of MCI. These subtypes are important, as they provide information regarding the type of dementia to which the patient is most likely to progress. Classification into subtypes is based on the number and the type of domain impaired. In this system, participants with only a memory impairment were classified as single domain amnestic MCI, and participants with a memory domain and another (language, executive functioning or visuospatial functioning) domain deficit was classified as multiple domain amnestic MCI. Participants with a single non-memory domain impairment were classified as single domain non-amnestic MCI. Finally, participants with more than one non-memory domain impairment were classified as multiple domain non-amnestic MCI.

Table 3. 3 Subtypes of MCI according to the conventional criteria and neuropsychological domains' deficits

Subtypes of MCI	**Memory Domain**	**Language Domain**	**Executive Functioning Domain**	**Visuospatial Functioning Domain**
	n (%)	n (%)	n (%)	n (%)
Single domain amnestic MCI (n=15)	15 (100%)	0	0	0
Multiple domain amnestic MCI (n=19)	19 (100%)	8 (42.11%)	8 (42.11%)	11 (57.9%)
Single domain non-amnestic MCI (n=30)	0	1 (3.33%)	8 (26.7%)	21 (70%)
Multiple domain non-amnestic MCI (n=4)	0	3 (75%)	1 (25%)	2 (50%)

Note. MCI = Mild Cognitive Impairment; n = percentage of participants in the MCI Conv group; n = number of participants; % = percentage

The subtypes based on the classification criteria revealed that the largest group met the diagnostic criteria for single domain non-amnestic MCI, followed by multiple domain amnestic MCI and single domain amnestic MCI. The group that met the criteria for multiple domain non-amnestic MCI was the smallest. The biggest number of deficits in people with multiple domain amnestic MCI was in the visuospatial functioning domain. The visuospatial domain was also most affected in people with a single domain non-amnestic MCI.

Part 2: Research Question One: Social Perception in MCI

The overall purpose of this thesis was to investigate social perception in people with MCI. As described earlier, the scores on the TASIT were not normally distributed and, therefore, non-parametric tests were used for the analyses. The Mann Whitney U test was used to compare the differences between the two groups on the total scores of the main subtests of the TASIT: recognition of emotions, social inference-minimal and social inference-enriched. Separate analyses for individual variables, such as recognition of individual emotions, were not carried out because of the risk of type 1 errors.

Because performance on the TASIT subtests was skewed, median scores are the appropriate representation of central tendency. However, the TASIT manual presents the normative data in the form of mean scores. Therefore, the results reported here include both median and mean scores.

Table 3.4 displays the TASIT scores for each group as well as between-group comparisons.

Table 3. 4 Descriptive statistics MCI Conv and non-MCI participants in their performance on the TASIT.

Variables in TASIT	**MCI-Conventional (n= 68)**			**Non-MCI (n= 49)**			**Mann-Whitney U Test Results**
	Median (IR)	*Mean (SD)*	*Range*	*Median (IR)*	*Mean (SD)*	*Range*	
Emotion Recognition Test							
Happy	3 (1)	3.21 (0.73)	2-4	3.5 (1)	3.33 (0.8)	1-4	
Surprised	4 (1)	3.69 (0.61)	1-4	4 (1)	3.65 (0.69)	1-4	
Neutral	3 (1)	2.78 (0.84)	0-4	3 (1)	2.77 (0.78)	1-4	
Sad	3 (1)	3.09 (0.93)	0-4	3 (0)	2.92 (0.74)	1-4	
Angry	3 (1)	3.22 (0.86)	1-4	3.50 (1)	3.33 (0.83)	1-4	
Anxious	4 (0)	3.87 (0.42)	2-4	4 (0)	3.69 (0.62)	2-4	
Revolted	4 (1)	3.32 (0.85)	1-4	4 (1)	3.48 (0.75)	1-4	
Total Positive Emotions	10 (2) [a=1]	6.69 (1.34)	3-12	10 (2) [a=3]	9.77 (1.68)	4-12	U = 1510.5, z = -0.891, p = .373, r = .007
Total Negative Emotions	14 (2) [a=13]	13.50 (2.02)	8-16	14 (2)* [a=5]	13.46 (2.2)	6-16	U = 1663.5, z = -.014, p = .989, r = 1.69
Total	23.50 (3)	23.21 (2.68)	16-28	24 (4)	23.23 (3.42)	14-28	U = 1581, z = -.473, p = .636, r =.002
Social Inference Minimal							
Sincere	16 (5) [a=11]	15.65 (4.03)	4-20	15 (6) [a=7]	14.38 (4.17)	4-20	
Simple Sarcastic	19 (3) [a=30]	18.18 (2.704)	8-20	19 (2) [a=17]	18.56 (1.61)	13-20	
Para Sarcastic	19 (2) [a=30]	18.53 (2.07)	12-20	19 (3) [a=22]	18.56 (1.96)	11-20	
Total	53 (7) [a=3]	51.76 (6.37)	27-60	52.50 (8)	51.96 (5.17)	38-59	U = 1585.5, z = -.261, p = .794, r = 5.92
Social Inference Enriched							
Lies	29 (5) [a=9]	27.78 (3.71)	18-32	28 (7)	26.48 (4.19)	17-31	
Sarcasm	26 (6) [a=1]	25.16 (4.25)	13-32	26 (6) [a=2]	25.77 (3.75)	15-32	
Total	53 (10)	52.43 (7.22)	36-63	53 (7)	52.33 (6.11)	32-62	U = 1561, z = -.399, p = .690, r = .0014

Note. MCI = Mild Cognitive Impairment; n = number of participants, IR = interquartile range, SD = standard deviation; [a] =number of participants obtaining perfect scores; U = Mann-Whitney statistic; r = effect size; p = < .05

The descriptive statistics presented in Table 3.4 show that most participants performed well on the TASIT. There was evidence of a ceiling effect on the TASIT variables; 44.12% of participants with MCI and 45.8% of participants without MCI had perfect scores on the subtest of recognition of paradoxical sarcasm. On recognition of simple sarcasm, 44.1% of participants with MCI and 35.4% of them without MCI had perfect scores. Additionally, fewer, 16.2% of the MCI population and 14.6% of people without MCI scored perfectly in identifying sincere messages. Twenty percent of the population with MCI and 10.42% without MCI obtained a perfect score. In recognising positive emotions, 1.5% of the MCI group and about 6.3% of the non-MCI got perfect scores. Given the high proportion of participants who obtained maximum scores, the medians of the group were high, especially in the recognition of simple and paradoxical sarcasm.

As can be seen in Table 3.4, both groups obtained similar scores on the main subtests of the TASIT. The Mann Whitney U test revealed no significant difference between the two groups in their performance on any of the TASIT subtest.

In order to explore the difference between the recognition of positive and negative emotions, further analyses were conducted. To begin with, the total scores for recognition of positive and negative were converted to percentages, because there were different numbers of items in the two groups. As there were no differences in positive or negative emotion recognition between the MCI and non-MCI groups, the data from the two groups were combined for this analysis. Wilcoxon Signed Ranks Test showed that the recognition of positive emotions (*Median* = 80.91) was significantly lower than the recognition of negative emotions (*Median* = 84.19), indicating that negative emotion recognition was

better than positive emotion recognition (Z = -2.98, p = .0003). However, the inclusion of neutral emotions as a positive emotion is not common in most studies of the field. Further, recognition of neutral emotions in the TASIT are difficult for most people. Therefore, neutral emotions were removed and analysis were conducted once again. Wilcoxon Signed Ranks Test showed that the recognition of positive emotions (Median = 86.32) was significantly higher than the recognition of negative emotions (Median = 84.19), indicating that positive emotion recognition was better than positive emotion recognition (Z = -2.98, p = .0003).

In order to investigate whether age was related to better recognition of positive or negative emotions, Spearman's correlations were carried out. The recognition of positive (r_s (115) = .014, p = .88) and negative emotions (r_s (115) = .19, p = .34) were not significantly related to age. Additionally, there was no significant difference between female and male participants in the recognition of positive (U = 1492.5, z = -.05, p =.96, r = 2.2) and negative emotions (U = 1471.5, z = -.18, p = .86, r = 2.8).

In conclusion, the participants' performance on the TASIT showed a substantial ceiling effect. Additionally, participant performance on the TASIT from the MCI Conv group did not significantly differ from the non-MCI group in their performance on the TASIT.

In order to explore the relationship between social perception and subtypes of MCI, three new groups were formed to include people who had multiple domain MCI, single domain MCI and non-MCI. Separate analysis between amnestic and non-amnestic MCI could not be conducted due to the small number of participants in these groups. Once again, non-parametric tests were used to

compare the medians of the three groups. Table 3.5 presents the descriptive statistics and results from the Kruskal-Wallis test.

Table 3. 5 Descriptive and inferential statistics between MCI Conservative and control group in their performance on the TASIT.

TASIT Subtest	**Multiple domain MCI (n=23)**			**Single-domain MCI (n=45)**			**Non-MCI (n=48)**			**Kruskal-Wallis Test Results**
	Median (IR)	*Mean (SD)*	*Range*	*Median (IR)*	*Mean (SD)*	*Range*	*Median (IR)*	*Mean (SD)*	*Range*	
Emotion recognition Total	23 (3)	23.3 (2.9)	16-28	24 (4)	23.2 (2.6)	16-27	24 (4)	23.23 (3.42)	14-28	χ^2 (2) = .265, *p* = .88
Social inference-Minimal	53 (8)	52.2 (5.8)	35-60	54 (7)	51.6 (6.7)	27-60	52.5 (8)	51.9 (5.2)	38-59	χ^2 (2) = .110, *p* = .95
Social inference-enriched	53 (8)	51.7 (8.5)	25-63	53 (11)	52.8 (6.5)	32-62	53 (7)	52.33 (6.1)	32-62	χ^2 (2) = .308, *p* = .86

Note. MCI = Mild Cognitive Impairment; n = number of participants group, SD = standard deviation; IR = Interquartile Range; *U* = Mann-Whitney statistic.
p = < .05, χ^2 = Chi-Square

Nearly 34% of the MCI Conv participants met criteria for multiple domain MCI, in comparison to 66.2% who had single domain MCI. All three groups performed similarly on the three subtests of the TASIT, showing almost identical medians across the subtests. The Kruskal-Wallis test revealed no significant differences among the three groups on the recognition of emotions, social inference-minimal and the social inference-enriched subtests.

In conclusion, performance on the TASIT did not differ between MCI Conv (all subtypes) and non-MCI participants. Similarly, there were no significant differences between mdMCI, sdMCI and non-MCI participants on any of the subtests of the TASIT. Further, the recognition of negative emotions was significantly better than the recognition of positive emotions in all the participants. Age was not significantly associated with the ability to recognise emotions or performance in any of the higher order social perception tasks.

Comparison between MCI participants and older adult normative data on the TASIT

There were no significant differences in performance on TASIT measures between people classified with MCI and those without MCI. This was found when participants were classified according to the conventional method or when analysis was conducted only using participants with a multiple domain MCI. This finding may be related to the nature of the community sample; it is possible that recruitment resulted in a sample that was unusually high functioning in the realm of social perception. The ceiling effects seen on the subtests of the TASIT further supported this.

This possibility was explored by comparing the performance on the TASIT by the MCI group to the normative, age-matched sample from the TASIT norms, which have recently become available (Mcdonald & Flanagan, 2017). These norms are available as means and standard deviations (rather than medians) by age group 40 to 59, 60 to 74 and 75 years and over. One-sample t tests were conducted to test the differences between the MCI conventional group and the TASIT norms. A comparison of the MCI group and normative group performance is presented in Figure 3.1.

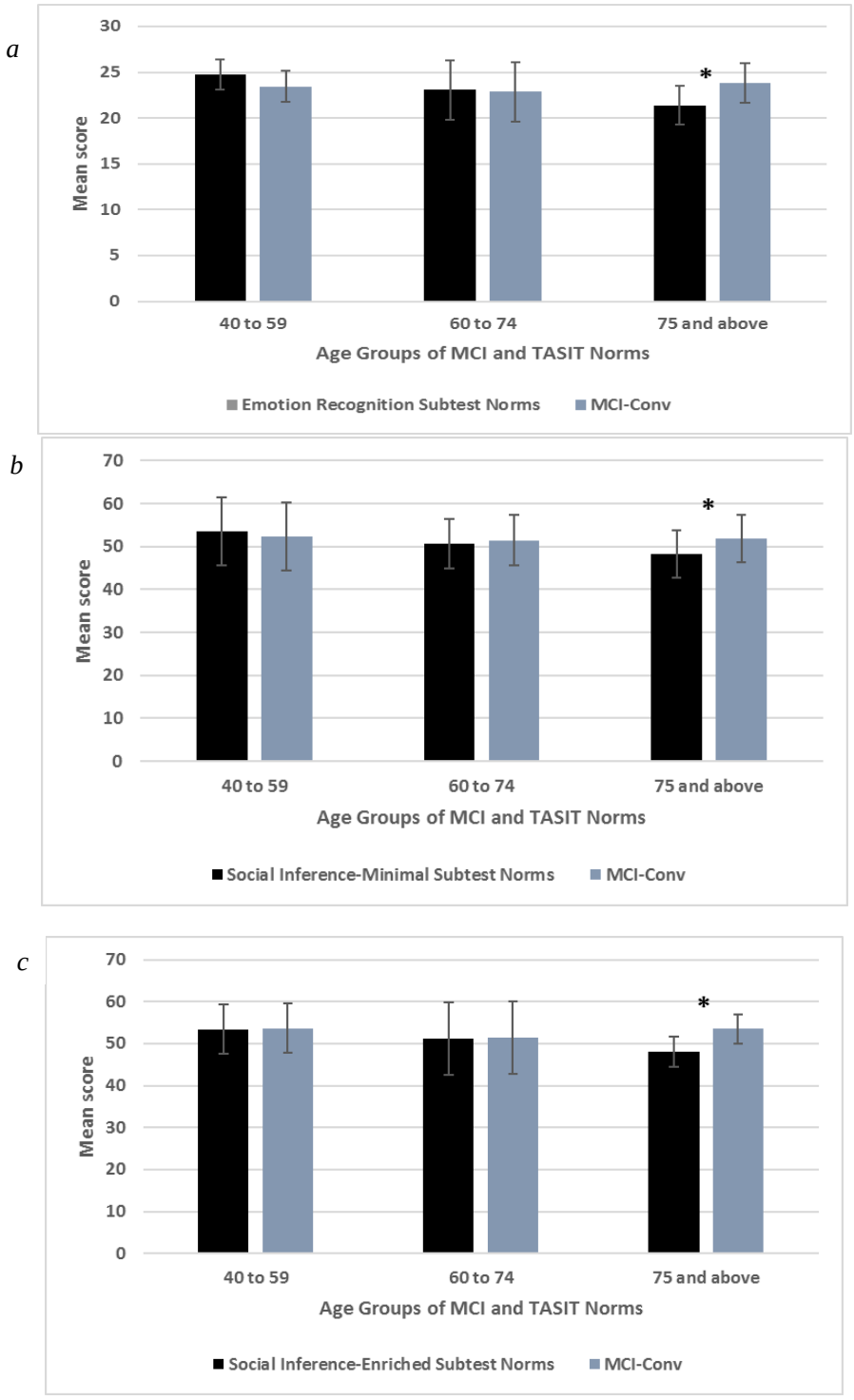

Figure 3. 1 Mean performance of the MCI-Conv group in comparison to TASIT norms on the emotion recognition subtest (a), social inference-minimal (b) and social inference-enriched (c). Data is presented as mean (SD).

Note: n (40-59) TASIT norms = 34, n (60-75) TASIT norms =187, n (75 and above) TASIT norms = 39, n (40-59) MCI-Conv =20, n (60-74) MCI-Conv =36, n (75 and above) MCI-Conv =12

The above figures depict the performance of the MCI Conv group in relation to the TASIT normative sample of older adults. The MCI Conv participants aged between 40 and 74 did not differ from the TASIT norms significantly on any of the subtests. However, participants above the age of 75 in the MCI Conv group performed significantly better than the TASIT norms, with moderate to high effect sizes, in the recognition of emotions *(t* (11) = 4, *p* = .002, *d* =.97), social inference-minimal (*t* (11) = 2.210, *p* = .049, *d* = .62) and social inference-enriched (*t* (11) = 5.292, *p* = <.001, *d* = .95) subtests.

Overall, the participants above the age of 75 in the current study did better than the norms on the TASIT. However, conclusions about statistical significance cannot be derived based on the small number of participants (12) present in the above 75 group.

Part 3: Research Question Two: What is the relationship between different cognitive domains and social perception?

While no differences between MCI Conv and non-MCI were found in social perception tests, it was still pertinent to examine the relationships between neuropsychological domains and social perception tests.

The analyses consisted of a series of correlations that examined the relationships between the TASIT subtests and the neuropsychological domain performance by the entire sample. Once again, non-parametric tests (Spearman's rho correlation) were conducted, because the TASIT variables were not normally distributed.

Table 3. 6 Spearman's rho correlations between social perception test scores of the TASIT (Part 1, 2 and 3) and neuropsychological domains

	Memory	**Language**	**Executive functioning**	**Visuospatial**
Emotion recognition	-.002	-.101	-.13	-.01
Sincere exchanges	.12	-.08	-.13	-.11
Simple sarcasm	-.12	-.09	.04	.09
Paradoxical sarcasm	-.13	-.13	-.11	.03
Social inference-Minimal	.03	**-.20*** (*p* = .029)	-.17	-.001
Lies	-.09	-.17	**-.19*** (*p* = .045)	-.03
Sarcasm	-.11	**-.20*** (*p* = .031)	-.15	-.08
Social inference-Enriched	-.11	**-.19*** (*p* = .046)	-.18	-.01

Note. SD = standard deviation, n = 116

***Correlation is significant at 0.05 level**

Table 3.6 presents the Spearman's correlations between emotion recognition, more complex social perception skills and the neuropsychological domains. The correlations among these sub scores of the TASIT and the neuropsychological domains are generally quite small. There was no relationship between emotion recognition and the neuropsychological domains. However, the language domain showed significant negative correlations with the social inference-minimal subtest, recognition of sarcasm and the social inference-enriched subtest. The executive functioning domain showed a small but significant negative correlation with the recognition of lying. The correlations need to be interpreted with caution, because the large number of participants obtaining maximum scores on the TASIT subtests meant that the range of scores was restricted. Further, the chances of type II errors were high because of the number of correlations that were conducted.

In addition to comparing neuropsychological domains and social perception subtests, relationships between social perception subtests were essential. To explore the relationship between the recognition of emotions and the recognition of higher order social perception tests, Spearman's correlation was carried out.

Table 3. 7 Spearman's rho correlation between recognition of emotions and higher order functioning variables of the TASIT (Part 2 and 3)

	Recognition of Emotion (n=117)
Sincere exchanges	.26** (*p*=.004)
Simple sarcasm	.17
Paradoxical sarcasm	.41** (*p*<.001)
Social inference-Minimal	.42** (*p*=<.001)
Lies	.31** (*p*=<.001)
Sarcasm	.37** (*p*=<.001)
Social inference-enriched	.43** (*p*=<.001)

Note. SD= standard deviation

****Correlation if significant at 0.01 level**

Table 3.7 depicts Spearman's correlations between the recognition of emotions and more complex social perception skills. There was a statistically significant positive correlation between the recognition of emotions and the recognition of sincere exchanges, paradoxical sarcasm, social inference-minimal, recognition of lies, recognition of sarcasm and social inference-enriched scores. Better emotion recognition was associated with better performance on the more complex social perception tests. As with the previous analyses, these findings need to be interpreted with caution due to ceiling effects on many of the TASIT subtests.

In summary, there was no clear relationship between the neuropsychological domains, the emotion recognition and the higher order social perception variables. As expected, emotion recognition was related to the perception of higher order social perception tests, although the interpretability of these findings is difficult due to the fact that TASIT has such a high ceiling effect.

Social Perception as a Neuropsychological Domain

Thus far, analyses have focused on the participants who met the criteria .6 for MCI and how they performed on the social perception test along with the overall relationship between social perception and cognitive functioning. However, focussing on group level data can obscure the fact that some participants within the groups may have social perception deficits. The variability of the scores on the TASIT (see Table 3.4 and 3.5), indicates that there were people in the sample who have deficits on certain subtests of the TASIT. To further explore the relationship between neuropsychological function and social perception, this section focusses on using the TASIT as a separate domain.

First, the TASIT norms were used to identify people who had deficits in the TASIT subtests. The TASIT manual provides cut-offs that determine three different levels of severity: mild, moderate and severe. The moderate (1.5 SD) level of severity was selected, as it was consistent with the cut-offs used to categorise participants with MCI according to the conventional method. This group will be referred as "impaired" in the TASIT. Table 3.8 presents the number of participants within the MCI Conv and Non-MCI group who met the "impaired" criteria in the TASIT. It also presents the descriptive statistics of their performance on the TASIT.

Table 3. 8 Medians, means, standard deviations and number of participants who were impaired (1.5 SD below mean) on TASIT subscales

	MCI-Conventional (68)			Non-MCI (49)		
	Median	**Mean (SD)**	**n (%)**	**Median**	**Mean (SD)**	**n (%)**
Emotion recognition Total	19 (4)	19.38 (2.3)	13(19.12%)	18 (7)	18.20 (3.16)	10(20.41%)
Social inference-Minimal	38 (10)	36.10 (5.86)	5(7.4%)	42 (6)	42 (3.2)	5(10.2%)
Social inference-enriched	41 (10)	37.86 (6.72)	7(10.3%)	38.5 (8)	37.75 (4.2)	4(8.2%)

Note. MCI = Mild Cognitive Impairment; SD = standard deviation; n = Number of participants in sample.

Overall, there were more people with deficits in the emotion recognition subtest, compared to the higher order social perception tests. Out of the total 117 participants, 19.6% participants showed deficits in the recognition of emotion, 8.6% showed deficits in the social inference-minimal and 9.5% showed deficits in the social inference-enriched subtests of the TASIT.

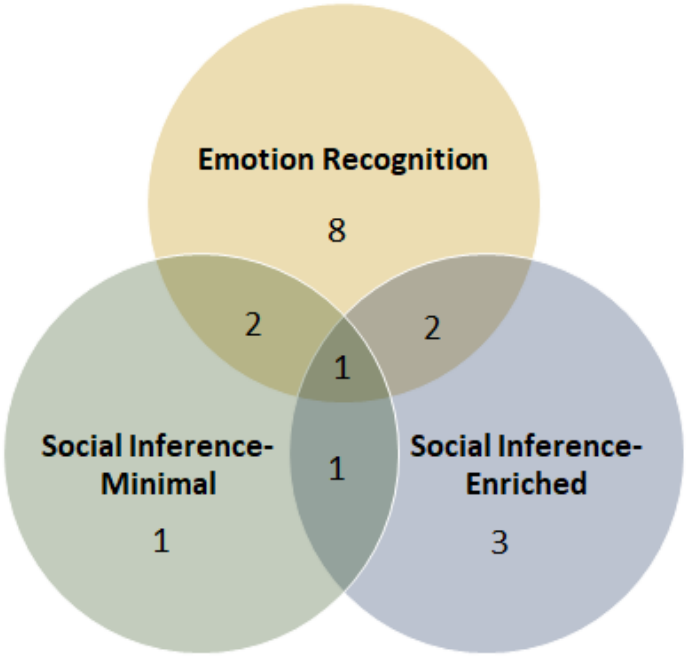

Figure 3. 2 Venn diagram showing number of participants with MCI Conv that have deficits on the subtests of the TASIT

The Venn diagram in Figure 3.2 displays the number of participants that show deficits on the different subtests in the TASIT. Twelve participants (17.65%) in the MCI group and 7 (14.6%) in the non-MCI group had deficits on one subtest of the TASIT. Five (7.4%) participants from the MCI group and one (2.1%) participant from the non-MCI group had deficits on two subtests of the TASIT. Finally, one (1.5%) participant with MCI and three (6.25%) participants without MCI had moderate deficits on all three subtests of the TASIT. One in five participants of the non-MCI group showed deficits in the recognition of emotion.

A chi-square analysis was carried out to examine the association between meeting the criteria for MCI and deficits in social perception. There was no significant association between meeting the criteria for MCI Conv and having impaired social perception for the emotion recognition test, χ^2 (14, N = 117) = 16.41, p = .29, social inference-minimal test, χ^2 (22, N = 116) = 17.16, p = .75 or

the social inference-enriched, χ^2 (26, N = 116) = 20.44, p = .77. Figure 3.3 shows a graphical representation of the data presented above.

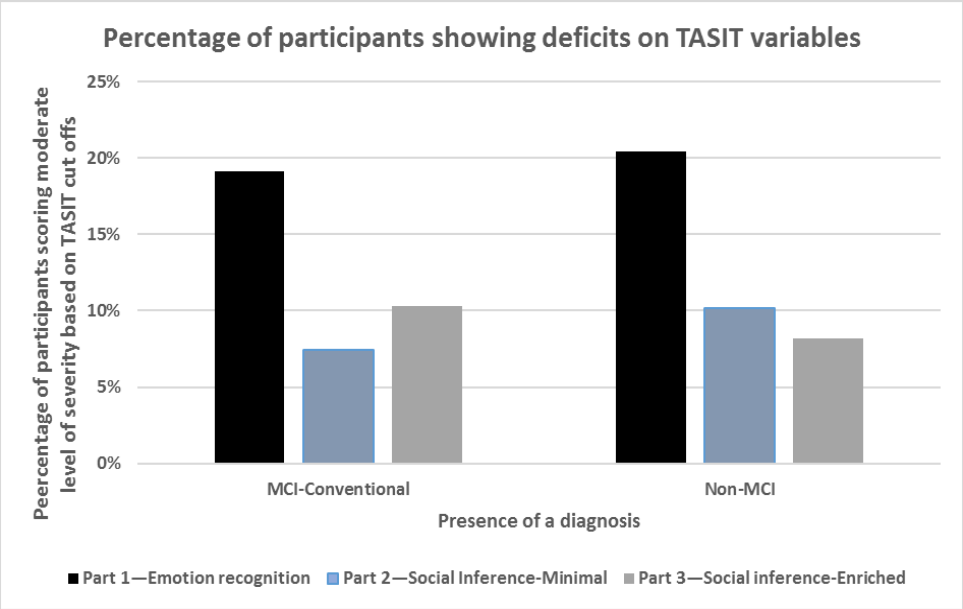

Figure 3. 3 Percentage of participants meeting the criteria for MCI conventional method and those who do not, who showed moderate deficits on the TASIT

Irrespective of MCI status, 19 participants showed moderate impairment on at least one subtest of the TASIT. In order to examine these deficits further, and to examine whether having multiple deficits within the social perception domain might be associated with broader impairment, further exploratory analyses were conducted.

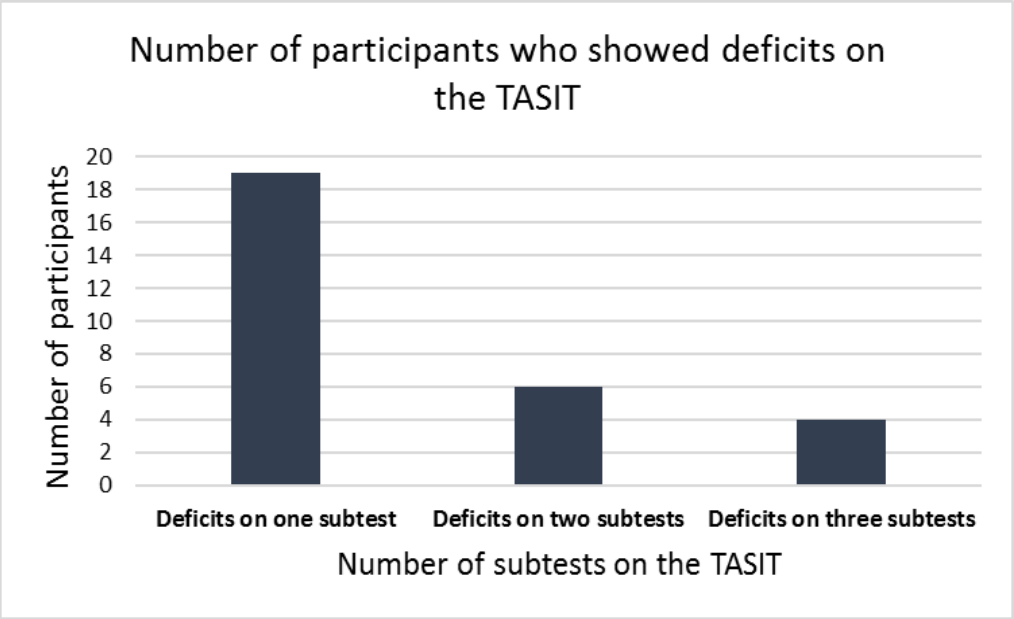

Figure 3. 4 Number of participants who had impairment on one, two or three subtests of the TASIT

Eighty-seven participants did not show any deficits on the TASIT. Nineteen participants had moderate impairment on only one subtest of the TASIT. Six had impairments on two subtests while four participants had impairments on all three subtests of the TASIT (see Figure 3.4).

Table 3.9 shows the demographic variables and the performance on neuropsychological measures among people with none, one, two or three deficits.

Table 3. 9 Means and standard deviations of demographic and neuropsychological domains of participants that showed deficits on one, two or three subtests

Demographic details	**No deficits (n=87)**		**Deficits on one subtest (n=19)**		**Deficits on two subtests (n=6)**		**Deficits on three subtests (n=4)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*
Age	65.9 (9.8)	46-88	60.7 (6.3)	51-74	61 (5.1)	53-67	61 (6.4)	55-67
Gender	F=59, M=28		F=12, M=7		F=3, M=3		F=4, M=0	
Education (y)	12.45 (3.2)	0-17	12.95 (2.9)	3-17	14 (.0)	14	10.5 (7)	0-14
	Mean T score (SD)	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*
Memory Domain	50 (4.11)	32.05-59.9	49.36 (5.8)	32.78-58.1	51.59 (2.7)	47.32-54.7	51.64 (2.9)	47.9-54.5
Language Domain	56.34 (8.7)	24-74	55.47 (8.2)	38.67-70	62.11 (5.1)	54.7-68	61.5 (4.9)	56.7-66.
Executive Functioning Domain	53.87 (8.8)	20-65.33	56.6 (4.7)	49.33-66.7	58.44 (3.7)	52.7-64	57.67 (3.6)	53.33-62
Visuospatial Functioning Domain	48.53 (5.7)	29.1-58.1	48.5 (5.6)	34.7-56.10	49.6 (4.3)	44.4-54.9	50.11 (2.2)	48.3-52.94

Note. SD = standard deviation, n = number of participants in sample.

In this sample, those with deficits on the TASIT were in the younger age ranges. People above the age of 75 fell into the criteria of no deficits, while quite surprisingly, the ones with the deficits on the TASIT were in the younger age range. The youngest participant with all three subtests impaired was only 55. Overall, people with deficits on one subtest performed lower on memory and language domains. People with no deficits on any subtest of the TASIT performed lower on the executive functioning domain and visuospatial functioning domain. Although formal statistics could not be performed, these differences appear quite small and not clinically significant.

The four participants with deficits in all three subtests of the TASIT were female. All four of these participants were recruited from the community and only one of them met criteria of MCI Conv; this was a single domain amnestic MCI. Six participants had deficits on two subtests of the TASIT, half of whom were female. Five of these participants met criteria for MCI according to the conventional criteria; three of them had a single domain MCI (one amnestic and two non-amnestic) and one multiple domain non-amnestic MCI. However, two of the groups were small, which did not allow more inferential statistics to be carried out. In addition to this information, it is of interest to explore the types of social perception deficits shown by participants who were in the “impaired” group.

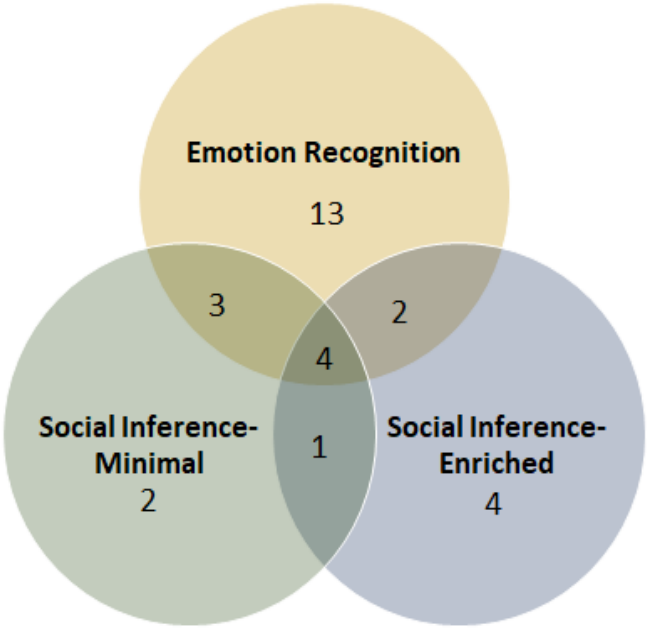

Figure 3. 5 Venn diagram showing number of participants that have deficits on the subtests of the TASIT

Figure 3.5 displays a Venn diagram of the number of participants who had deficits the different subtests in the TASIT. Almost all (75.8%) participants met the cut-off for impairment on the recognition of emotion recognition. Most of the participants (13, 68.4%) with impairments on one subtest had impairments on the recognition of emotion. Two participants (10.5%) had deficits on only the social inference-minimal subtest. Four participants (21.05%) had impairments on only the social inference-enriched subtest. Three participants (50%) had impairments on both emotion recognition and social inference-minimal subtests; two participants (33.3%) had impairments on emotion recognition and social inference-enriched, and one participant (16.7%) had impairments on social inference-minimal and social inference-enriched. Four participants had deficits on all three subtests of the TASIT.

In conclusion, when social perception was considered a separate domain, using the TASIT to classify participants as having deficits based on the provided norms, the most common deficits were in emotion recognition. As already

established, the deficits on the TASIT were not related to the MCI classification. Considering only social perception, most of the participants in the current study, regardless of classification, did not have any deficits on the TASIT and only four of them (3.4%) had deficits on all subtests.

Part 4: Social and Informant Measures

The final stage of analysis was to examine the measures of social activity and network, informant perspective on activities of daily functioning and cognitive decline in the participants with MCI and non-MCI. Additionally, social activity and informant measures between participants with and without deficits on social perception tests were explored.

An important question was the relationship between informant's perspective on the participant's level of functioning and deterioration from their premorbid level of functioning. The informant for each participant also provided information regarding cognitive impairments and decline across ten years. It was thus useful to look at the relationship between informant reporting and the classification of MCI.

Informant measures

There were two informant measures (IADLS and the IQCODE) that looked at the current activities of daily living and decline from premorbid functioning, respectively. Lower scores on the IADLS indicate greater deficits in activities of daily living. Low scores on the IQCODE indicated more decline in cognitive functions in the last ten years, according to the informant. Although some informants were met face to face, around 85% of the informants opted to mail the completed questionnaires back. Not all of them returned the completed questionnaires, and some participants lived on their own. Of the 68 MCI Conv participants, 43 (63.2%) had informant questionnaires, and out of 49 participants from the non-MCI group, 31 (63.3%) had questionnaires. In the MCI Conv group, 26 informants were partners of the participants, ten were children, four were

friends or colleagues and the rest (three) were other relatives such as siblings and cousins. Among the non-MCI group, 20 of the informants were partners of the participants, five were children of the participants, three were friends, and all the others (three) were other relatives. A visual inspection of the histograms of the informant measures as well as the KS statistic for the IADLS, D (74) = .46, p = <.001, and the IQCODE, D (74) = .21, p = <.001, suggested that the dataset was not distributed normally. Hence, non-parametric tests were used in the subsequent analyses.

Table 3. 10 Performance ratings on the IQCODE and the IADLS between MCI and non-MCI groups

Informant Measures	**MCI-Conventional (n=43)**			**Non-MCI (n= 31)**		
	Median (IR)	*Mean (SD)*	*Range*	*Median (IR)*	*Mean (SD)*	*Range*
IADLS	8 (0)	7.6(1.3)	2-8	8 (0)	7.84 (0.52)	6-8
IQCODE	3 (0.32)	3.1 (0.48)	2.11-4.7	3 (0.2)	2.9 (0.21)	2.11-3.3

Note. MCI = Mild Cognitive Impairment; n = number of participants; SD = standard deviation; IADLS = Instrumental Activities of Daily Living Scale; IQCODE = Informant's Questionnaire on Cognitive Decline in the Elderly
* p<0.05 all p values based on Mann Whitney U-test comparisons

The informant ratings on the IADLS and the IQCODE were compared between the MCI Conv and the non-MCI group. The highest possible score for the IADLS was eight and the mean scores for both groups were close to this score. The IQCODE is calculated as an average score of the items, and ratings between 3.3 and 3.6 are suggestive of cognitive decline from a premorbid level of functioning. On average, both groups fell outside this range, although there were a few people who had higher scores on the IQCODE (see upper limit of range in

Table 3.10), suggesting that only a small number of participants were rated as showing significant cognitive decline by their informants.

The groups showed similar scores on the IADLS, and the non-MCI group had slightly lower scores on the IQCODE. There was no statistically significant difference between the MCI Conv and non-MCI on the IADLS (U = 665, z = -0.61, p = .543, r = .005). On the other hand, there was statistically significant differences between the two groups on the IQCODE (U = 475, z = -2.13, p = .033, r = .06).

Social Measures

In addition to informant measures, assessment of social activities was collected from participants via two questionnaires–the Social Activity Log (SAL) and the Lubben Social Network Scale (LSNS). The ratings on the social activity and social network scales between MCI and non-MCI groups were compared.

The presence and frequency of engagement in different social activities was collected using the SAL, and the frequency of social networking with friends and family was collected using the LSNS. High scores on the SAL and the LSNS indicate more social activity and closer relationships between participants and their close ones, respectively. The LSNS consists of two subscales: network with friends and network with family. The items on the SAL are divided into non-contact events, such as: email and telephone calls; regular events such as meeting the other for coffee, tea, drinks, visits to people's homes; and special events which consists of social events such as concerts, theatre, and going to the cinemas. In this phase of analysis, the MCI Conv and the non-MCI groups were compared on their responses to the two social measures. As the data were not normally distributed, non-parametric tests were used. Table 3.11 presents the descriptive

and inferential statistics of the two groups and their responses to the LSNS and the SAL.

Table 3. 11Descriptive and inferential statistics of performance on the Lubben Social Network Scale (LSNS) and social activity log (SAL) between MCI and non-MCI groups

Social Measures	**MCI-Conventional (n= 68)**			**Non-MCI (n= 49)**			**Mann-Whitney U Test Results**
	Median (IR)	*Mean (SD)*	*Range*	*Median (IR)*	*Mean (SD)*	*Range*	
Family	11 (5)	10.41 (3.1)	5-15	12 (3) *	11.57 (2.2)	6-15	U = 1311.5, z = -1.971, p = .049, r = .033
Friendships	9 (5)	9.03 (3.8)	0-15	11 (5) *	11.12 (2.9)	4-15	U = 1148.5, z = -2.872, p = .004, r = .07
LSNS	19.50 (9)	19.10 (5.8)	1-29	24 (6) *	22.51 (4.18)	13-30	U = 1092, z = -3.178, p = .001, r = .09
Non-contact events	18 (4)	15.63 (3.8)	3-18	18 (2)	16.73 (1.9)	11-18	U = 1534.5, z = -.811, p = .417, r = .006
Regular events	12 (11)	12.37 (6.5)	0-26	13 (8)	13.31 (5.4)	2-26	U = 1499, z = -.925, p = .355, r = .007
Special events	2 (5)	3.06 (3.33)	0-15	3 (4)	3.73 (2.9)	0-12	U = 1353.5, z = -1.743, p = .081, r = .026
SAL	31 (15)	31.06 (10.23)	6-48	34 (8)	33.78 (7.63)	15-50	U = 1428, z = -1.316, p = .188, r = .015

Note. MCI = Mild Cognitive Impairment; n = number of participants; SD = standard deviation; LSNS = Lubben Social Network Scale; SAL = social activity log

* $p<0.05$ all p values based on Mann-Whitney U Test comparisons

The results presented on Table 3.11 show that the participants in the MCI Conv group had significantly lower scores on all the LSNS compared to the non-MCI group. There seems to be a pattern of generally more social events for the non-MCI group, but it was not statistically significant. When Mann Whitney U tests were carried out, the MCI Conv group had significantly less social contact with their families (low effect size), and their friends (medium effect size) compared to the non-MCI group. Overall, the MCI Conv group had lower social network scores (low effect size) compared to the non-MCI group.

It was also of interest to explore the social network and social activity in people with deficits on the TASIT, in order to explore differences between groups that had fewer and more deficits on the TASIT. However, due to uneven group size and two groups with very small sample size, meaningful descriptive analysis could not be carried out.

Table 3. 12 Descriptive statistics of ratings on the Lubben Social Network Scale (LSNS) and social activity log (SAL) groups based on number of impaired subtests of the TASIT

Social Measures	**Deficits on one subtest (n=19)**			**Deficits on two subtests (n=6)**			**Deficits on three subtests (n=4)**		
	Median	*Mean (SD)*	*Range*	*Median*	*Mean (SD)*	*Range*	*Median*	*Mean (SD)*	*Range*
Family	11	10.8 (2.7)	5-15	10	10 (3.7)	5-15	13	13 (1.83)	11-15
Friendships	12	10.7 (3.3)	1-15	10	9.8 (2.9)	6-13	12	11.5 (3.7)	7-15
LSNS	22	21.5 (4.7)	10-28	21	19.8 (6.3)	11-28	25.5	24.5 (5.4)	18-29
Non-contact events	18	15.8 (4.03)	6-18	18	17.2 (1.6)	14-18	17	17 (1.2)	16-18
Regular events	12	12.3 (6.3)	5-26	12	12.8 (3.3)	9-19	12	12 (2.6)	9-15
Special events	4	3.9 (2.7)	0-8	4	3 (2.45)	0-6	4.5	4 (2.9)	0-7
SAL	34	32 (10.04)	12-48	32.5	33 (4.82)	26-40	33.5	33 (3.6)	29-36

Note. MCI= Mild Cognitive Impairment; n=number of participants; SD= standard deviation; LSNS= Lubben Social Network Scale; SAL= social activity log

Table 3.12 shows descriptive statistics for the LSNS and the SAL among three groups of all participants who showed at least moderate impairment on one, two or three subtests of the TASIT. The most impaired group appeared to have slightly higher scores on the social network measures, but very small sample size means this is very tentative. There was no consistent pattern of differences among the groups on the social activity measure.

In conclusion, there was no difference between the MCI Conv and non-MCI groups on the informant measures. The MCI Conv group had significantly poor social networking with family and friends. Although formal statistical analysis could not be carried out, the most impaired group appeared to have slightly higher scores on the social network scale.

Summary of findings

Participants in the current study who had a diagnosis of MCI according to the conventional criteria did not significantly differ in their performance on the TASIT compared to the non-MCI group. When comparing participants who had only md-MCI and those with sd-MCI and non-MCI, there was still no difference between the groups in their performance on the TASIT. For the entire group, the recognition of positive emotions was significantly poorer than the recognition of negative emotions, and age was not related to this. Substantial ceiling effects were found on the TASIT for both MCI and non-MCI groups, and these ceiling effects made it hard to interpret the correlation analysis with the neuropsychological domains, which found the language domain to be weakly negatively correlated with two main subtests (social inference-minimal and social inference-enriched) and the recognition of sarcasm. Furthermore, executive functioning was slightly

negatively correlated with the recognition of lies. As expected, emotion recognition was positively correlated with the recognition of the higher order social perception skills.

Examination of the characteristics of the participants showing deficits on the TASIT subtests showed that the majority of participants did not show any deficits and most of the participants with deficits were impaired on only one subtest, which was most commonly recognition of emotion. Further, there was no relationship between the presence of an MCI Conv diagnosis and deficits on the TASIT. The MCI Conv group did not differ from the non-MCI group in the informant ratings of activities of daily living and cognitive decline from premorbid level of functioning. Finally, the MCI Conv group had significantly smaller social networks with friends and family.

Chapter 4-Discussion

The main aims of this thesis were to explore social perception in mild cognitive impairment (MCI) and to examine the relationship between social perception and neuropsychological function. More specifically this research explored several aspects of social perception including emotion recognition (happy, surprised, neutral, sad, angry, anxious and revolted) and two examples of higher order social perception skills (recognition of lying and sarcasm). It also incorporated collateral information on social functioning, and examined the relationship between this and direct assessment of social perception and neuropsychological functioning.

Assessments were conducted on a community sample of people over the age of 50 years and a group of participants who had received a diagnosis of MCI from the local District Health Boards (DHBs). There is a lack of consensus in the literature regarding the most appropriate MCI classification criteria (Jak et al., 2009; Petersen, 2004; Ritchie & Tuokko, 2010). The first analysis in this study focussed on identifying all participants (community and DHB) who met various published classification criteria (liberal, conventional, comprehensive and conservative) related to MCI. The conventional criteria (1.5 SD below age appropriate mean) provided the classification that appeared to be the best fit, classifying all DHB patients and 49% of community participants as having MCI. All other community participants were assigned to the non-MCI group. The conventional criteria (1.5 SD below mean on any one test of a domain) thus classified 68 participants (58%) with MCI, leaving 49 (42%) participants who did not have MCI according to these criteria.

Social perception in people with mild cognitive impairment (MCI)

Based on the literature (e.g., Anderson et al., 2013; Baglio et al., 2012; Bora & Yener, 2017; Fujie et al., 2008; Gaudreau et al., 2015a; Moreau et al., 2015; Poletti & Bonuccelli, 2013b; Teng et al., 2007), it was expected social perception would be worse for participants with MCI compared to those without MCI. Contrary to expectations, there were no significant differences between the MCI and non-MCI participants in their performance on social perception subtests. When using cut-off criteria that identified people with moderate deficits on the TASIT, a quarter of all the participants showed deficits, and there was no significant association between MCI diagnosis meeting criteria for moderate deficit on the TASIT. In comparison to single domain MCI, multi domain MCI has found to be better predictor of dementia (Rasquin, Lodder, Visser, Lousberg, & Verhey, 2005). Hence, new groups were formed to include only those participants who had multi domain MCI and analyses was conducted to compare three groups: multi domain MCI, single domain MCI and non-MCI. Contrary to other published studies (Teng et al., 2007; Weiss et al., 2008), participants showing multi domain MCI did not differ significantly from the single domain and non-MCI participants in their performance on the social perception subtests.

Recognition of emotions among older adults

Studies have found that older people performed better at the recognition of positive emotions compared to negative ones (Calder et al., 2003; Fujie et al.,

2008; Moraitou et al., 2013b; Moreno, 1993; Phillips, Maclean, & Allen, 2002; Sullivan & Ruffman, 2004). The present study found that older participants were better at recognising positive emotions compared with negative emotions. This result was found after the exclusion of neutral emotions from positive emotions. The TASIT differs from other tests used in previous published studies in specific emotions studied. Positive emotions in the TASIT include happy, surprise and neutral. Most of the previous studies have included only happy and surprise as positive emotions. Other studies have classified the recognition of neutral expressions as a separate emotion that is neither positive nor negative (e.g., Abram et al., 2014; Forgeard, 2011; Kopelman, Rosette, & Thompson, 2006). The neutral emotions in the emotion recognition subtest of the TASIT are the most difficult to interpret as they tend to be ambiguous (McDonald et al., 2006; Moraitou, Papantoniou, Gkinopoulos, & Nigritinou, 2013a). This result is consistent with the other studies that have found that certain negative emotions such as fear, sadness and anger were more difficult for older people to recognise than the positive ones (Calder et al., 2003; Fujie et al., 2008; Moraitou et al., 2013b; Moreno, 1993; Phillips et al., 2002; Sullivan & Ruffman, 2004). This finding from the current study is also consistent with the theory of positivity bias, which postulates that as people grow older, they tend to focus more on positive aspects of emotions (Carstensen & Mikels, 2005), making the recognition of negative emotions less accurate than positive emotions.

Social perception and neuropsychological functioning

The next focus of this research was regarding the relationship between social perception and cognitive functioning across four domains. Contrary to findings in

other studies (Adolphs, 1999b; Keulers et al., 2010), due to the ceiling effects of the TASIT, it was concluded that there was no significant relationship between emotion recognition and higher order social perception skills. Consistent with prior literature (Dimberg & Thunberg, 1998; Marrero-Fernández, Montoya-Padrón, Jaume-I-Capó, & Buades Rubio, 2014; Tracy & Robins, 2008; Zimmerman et al., 2016), emotion recognition did not relate to neuropsychological functioning. Emotion recognition is an automatic task and does not require complex cognitive processes such as memory, executive functioning, language or visuospatial function. There was also no relationship between higher order social perception abilities and neuropsychological functioning. Specifically, there was no relationship between the recognition of paradoxical sarcasm and language in the current study as interpreted due to the small correlations present, which was in contrast to findings by McDonald et al. (2014) who found that poor ToM performance was related to poor executive functioning in participants and results from Symington et al. (2010), who found that recognition of paradoxical sarcasm, particularly with textual cues, was related to language functions in participants with complete agenesis of the corpus callosum. Further, Rankin et al. (2009) found a positive relationship between higher order social perception tasks of the TASIT and neuropsychological domains of language and verbal memory in people with dementia.

Although emotion recognition was independent of cognitive functioning, there were differences in performance across people. When looking at performance on all subtests of the TASIT, participants were worse on the emotion recognition subtest compared to the higher order social perception tasks. When using the suggested cut-offs to identify participants with moderate deficits on the TASIT, almost all participants showed deficits on the recognition of emotion.

However, once again, these deficits were not related to neuropsychological functioning. The finding that participants performed better on the higher order social perception tasks compared to the recognition of emotion is inconsistent with other research, especially neurobiological (for review, see Adolphs, 2003) and developmental research (Heck et al., 2018; Minagawa-Kawai et al., 2009). The difference in the findings in the current research may be attributable to the TASIT as discussed in a later section.

Discrepancies with prior research

There are several possible explanations for why the current results depart from previous studies' findings, including recruitment methods, classification of MCI, classification of subtypes of MCI, age of participants and the measures used to assess social perception, including ceiling effects on the TASIT.

While most studies (Anderson et al., 2013; Fujie et al., 2008; McCade, Savage, Guastella, Lewis, et al., 2013; McCade, Savage, & Naismith, 2012b; Pietschnig et al., 2015; Teng et al., 2007; Weiss et al., 2008; Yang et al., 2015) have classified people with MCI using the same criteria (conventional criteria) as the present research, most participants in those studies have been recruited through clinical settings (Anderson et al., 2013; Fujie et al., 2008; McCade, Savage, Guastella, Hickie, et al., 2013; Pietschnig et al., 2015). For example, McCade, Savage, Guastella, Hickie, et al. (2013) recruited 56 participants who were registered at the Centre at the Brain and Mind Research Institute in Sydney, Australia, all of whom were concerned about their cognitive problems and were referred to the centre by clinicians including neurologists, psychiatrists and geriatricians. A clinical sample of participants is more likely to include

participants who show widespread neuropsychological deficits affecting more aspects of daily functioning compared to people recruited through the community. Although by most definitions, people with MCI need to be functional in their basic activities of daily living (ADLs) (Greenaway et al., 2012; Petersen et al., 1999; Rasquin et al., 2005; Summers & Saunders, 2012), there have been inconsistencies whereby some studies have found variation from none to large declines in ADLs among people with MCI (Lindbergh et al., 2016). In other words, people clinically diagnosed with MCI could have considerable deficits in their basic everyday functioning. Additionally, complex ADLs, such as driving, cooking and managing finances tend to be affected in people clinically diagnosed with MCI (Albert, Michaels, Padilla, & Pelton, 1999). Although not an exclusion criteria in the present study, information regarding basic activities of daily living were collected from informants and overall, the present study's MCI group reported little or no decline in ADLs. The present study includes a large (almost 70%) proportion of community-recruited participants who were then classified as MCI. While the second phase of community recruitment included participants who had a cognitive complaint, many did not voice any specific concerns, and so might best be considered 'sub-clinical', and likely less impaired than a clinically-recruited sample.

Concerning the lack of relationship between neuropsychological functioning and higher order social perception tasks, probably the most important difference between the present study and others mentioned above is the level of cognitive dysfunction in the populations studied. The present study consists of people from the non-MCI group who were mostly healthy and the MCI group that is sub-clinical who by definition did not have a known neurological condition (as determined by the exclusion criteria). In contrast, previous studies consisted of

participants with more neurological impairment. For example, Symington et al. (2010) used participants who had a complete agenesis of the corpus callosum, an important structure of the brain that supports the interaction between the two hemispheres. Rankin et al. (2009) assessed people with dementia. McDonald et al. (2006) study sample consisted of people with traumatic brain injuries.

Another possible explanation for the different results of the current study compared to prior research was the method of classification of MCI. There is a general lack of consensus regarding the best way to diagnose MCI. Although neuropsychological assessments serve as a good tool of classifying MCI (Jak et al., 2009), other factors such as informant ratings, biological markers and clinical history to determine premorbid levels of functioning have been shown to be useful in improving the robustness of the classification of MCI (Ewers et al., 2012; Mattsson et al., 2009; Winblad et al., 2004) and these have been used in other studies of MCI (Albert et al., 1999; Marras et al., 2013). The classification of MCI in the community-recruited participants in this study focussed only on the neuropsychological functioning of participants.

Another distinguishing feature of studies that reported a difference on social perception in MCI is the inclusion of specific subtypes. Multiple domain MCI has been found to be associated with widespread deficits in cognition and social functioning. Many of the previous studies have only used participants with multi domain MCI (34% of the MCI Conv group in the current study) (Baglio et al., 2012; Maki et al., 2013; McCade, Savage, Guastella, Lewis, et al., 2013; McCade et al., 2012b; Poletti & Bonuccelli, 2013b), and others have not differentiated between single and multiple domain subtypes (Pietschnig et al., 2015; Yang et al., 2015). Further, some previously published studies have only included participants with amnestic MCI (Baglio et al., 2012; Bora & Yener,

2017; Gaudreau et al., 2015a; Maki et al., 2013; Moreau et al., 2015; Poletti & Bonuccelli, 2013b), which is linked to degeneration in the prefrontal cortex (Chang et al., 2010; Mufson et al., 2012) and abnormalities in the cortical thickness of the frontal lobes (Chang et al., 2010). The present study included amnestic and non-amnestic MCI participants, with only half of the participants meeting the criteria for amnestic MCI. Additionally, the present study included a small proportion of participants who had multi domain non-amnestic MCI (28%); the largest percentage had single domain non-amnestic MCI (44%). The people with single domain non-amnestic MCI have been found to show a relatively higher chance of reverting to normal cognition (Diniz, Nunes, Yassuda, & Forlenza, 2009; Forlenza et al., 2009; Ritchie & Tuokko, 2010) and thus may have more intact neuropsychological functioning.

Average age of the participants. The average age of participants in the present study was lower (66 years) than that found in most other studies mentioned. Hence, factors associated with age might have contributed to some of the results found, especially the lack of differences between single domain and multi domain MCI. For example, Maki et al. (2013) included participants with MCI and older healthy adults whose mean ages were 74 years and 72 years respectively.

Another reason for the differences in findings may be the measure used to assess emotion recognition and complex social perception abilities. Most of the previous studies used static visual, audio based or story based assessment stimuli, capturing only one modality at a time, such as visual or audio. For example, Teng et al. (2007) used the Florida Affect Battery (FAB) and Weiss et al. (2008) used the Venn Emotion Recognition Test to assess the recognition of emotion. Both of these tests assess emotion recognition using static photographs of people

displaying basic emotions. Additionally, the tasks used in prior studies have been relatively cognitively demanding. The tasks have less information available and adds the cognitive load of the participant to rely on subtle cues. A meta-analysis of social perception in MCI by Bora and Yener (2017) speculated that impairments found on Theory of Mind (ToM) are due to the cognitively challenging nature of the tests, such as Reading the Mind in the Eyes Test (RMET). In other words, an additional cognitive load was placed by these tests and these errors might be differentially more likely among people with cognitive deficits.

The current and previous studies differs in the types of emotions assessed. Neither of the tests used in prior studies (FAB and Venn Emotion Recognition Test) included assessment of recognition of surprise or disgust. The studies only included recognition of happiness, sadness, anger, fear and neutral emotions. Recognising emotions through pictures is often confusing. For example, the recognition of surprise is frequently confused with fear (Adolphs, 2002; Rapcsak et al., 2000). On the other hand, certain positive emotions, such as happiness, are relatively easy to recognise, resulting in ceiling effects (Ruffman et al., 2008b).

Characteristics of the TASIT

The present study used the TASIT, which consists of dynamic videos of live actors, including information like facial movement, prosody, tone of voice and gestures, to assess the recognition of all the basic emotions (Alves, 2013; McDonald et al., 2004). In real life, although facial emotion recognition is important, a lot of information is derived from other cues such as head tilts (Rosenberg & Ekman, 1995), contextual cues (Ludlow et al., 2014), and prosody

(Ruffman et al., 2009). Studies have found that peoples' recognition of emotions are generally better when the stimuli used are of a dynamic nature rather than static photographs (Wehrle, Kaiser, Schmidt, & Scherer, 2000) and therefore cognitive capacity has more of an effect in deciphering emotions from static visual stimuli compared to dynamic stimuli. In other words, the findings from the previous published studies may have been due to the difficulty of the task rather than reflecting deficits in social perception.

In the present study, the TASIT displays a wider range of emotions (happy, surprised, neutral, sad, angry, anxious and revolted) and includes more information than just voices or only faces, creating a different and richer set of stimuli to evaluate emotion recognition.

Having to decide whether a particular video is of an emotional nature or not seems to be what contributes to the difficulty of this task (McDonald et al., 2006; McDonald et al., 2003a; Moraitou et al., 2013a).

The TASIT differs from other tests used in previous published studies in specific emotions studied. The fact that the TASIT did not show many ceiling effects on recognition of happiness suggests that the test has been able to correct for the overly easy nature of detecting happiness that has been reported in other studies. Further, the emotion recognition subtest of the TASIT has improved the validity of the depiction of certain emotions like fear by increasing the number and accuracy of cues such as tone of voice.

Another interesting finding in the current research was that participants performed very well, with many reaching the test ceiling, on higher order social perception tasks. In the recognition of more complex social perception tasks, the TASIT contains contextual, background information that made the recognition of

complex social perception tasks such as sarcasm, lies, and inference about another person's intent relatively easy and accurate for a large portion of participants.

The TASIT is a useful tool developed for assessing social perception in people with significant neurological problems. The TASIT has been used extensively with people with brain injuries (McDonald et al., 2013), dementia (Kipps et al., 2009; Rankin et al., 2009) and psychiatric (Ladegaard, Larsen, Videbech, & Lysaker, 2014; Rocca et al., 2016) and developmental conditions (Zimmerman et al., 2016). The TASIT is the only ecologically valid test that assesses nuances of emotion recognition and social inference. However, because of ceiling effects such as those found in this study, it may be less useful in people with less severe neurological conditions.

Clinical implications of the study

This study has clinical implications for primary level care in terms of early screening, assessment of MCI and rehabilitation goals. The study of early symptoms for various types of dementia has been growing steadily in the last few decades (Gansler et al., 2017; Gu et al., 2017; Tzeyu et al., 2017). While research in the study of Alzheimer's disease is a main focus of ageing research, the study of other kinds of dementia, including the frontotemporal type, is still in its infancy. One of the major early symptoms of behavioural variant frontotemporal dementia (bvFTD) is difficulties in social interaction (Bott et al., 2014; Fernandez-Duque & Black, 2005; Karageorgiou & Miller, 2014; Kipps et al., 2009). This includes behavioural changes, impulsivity, social inappropriateness and a lack of insight. A change in social perception abilities could be an early sign

for those most likely to develop frontotemporal dementia (Bora, Velakoulis, & Walterfang, 2016; Bora et al., 2015; Goodkind et al., 2015; Henry et al., 2014). Frontotemporal dementia (FTD) begins earlier in life, is fast progressing and is associated with symptoms that prevent early intervention, i.e., lack of insight. The present study has important implications in assessment of possible early signs of FTD. There is a subset of people who do not show impairment in neuropsychological tests, but do have deficits in social perception. It is not known whether this is a decline from premorbid social perception functioning or a stable weakness. However, this pattern might be a risk factor for FTD, which can be investigated through longitudinal studies. It is suggested that information regarding social perception changes such as understanding emotions and higher order changes such as ToM, sarcasm and empathy might be an important first point of assessment.

Information from caregivers is paramount in the early identification of someone who may have a risk of developing frontotemporal dementia. However, the focus of primary intervention has been on people who have a greater risk of developing Alzheimer's disease. In the assessment of MCI in New Zealand at present, general practitioners conduct an initial screen of people who have memory complaints and unless complicated, treat them conservatively (fewer follow ups) with some lifestyle advice, including making people aware that they can refer themselves to speciality services if they see further changes, and also provide treatment for any suspected underlying problems such as anxiety, depression, deficiencies, or alcoholism (Ministry of Health, 2013). However, in cases of changes in social perception, even subtle, someone as young as 50 years may warrant quicker assessment and intervention as they may be potentially at risk for FTD.

Social perception as a domain of neuropsychological functioning

Aspects of social perception, both basic (emotion recognition) and higher order, or more complex functions such as the recognition of sarcasm and lying, appear to be independent of cognitive functioning. Social perception has evolved in humans because it is required for us to because it was an advantage in social interactions. The fact that social perception is not related to neuropsychological functioning is consistent with biological findings. The neurological underpinnings of cognitive domains are different from the neurological underpinnings of social perception (Adolphs, 1999a; Adolphs & Tranel, 2003). This has clinical and research implications. In the field of neuropsychological testing, the inclusion of social perception deficits as a separate domain is potentially useful in forming a widespread picture of a person's functioning - one that has greater real life implications. For example, deficits in emotion recognition may lead to problems in friendships that lead to loneliness and isolation. Loneliness and isolation may then influence wellbeing and even rates of mortality (Bath & Deeg, 2005; Fry & Debats, 2006). Not being able to detect lying may make people more vulnerable to falling for financial fraud (Lichtenberg et al., 2013).

The TASIT may be a useful tool for recognising people who have moderate to severe social perception problems and has been proven useful in assessing social perception in older people in the current study. The inclusion of social perception as a separate domain may point to subtypes of MCI that indicate risk of developing frontotemporal dementia, especially the behaviour variant.

Assessment of social perception contributes to diagnostic processes. The understanding of deficits in social perception has implications in psychoeducation

for caregivers who are often the ones who deal with difficult behaviour (Bott et al., 2014). For example, people with behaviour variant FTD often have changes in social perception, leading them to behave uncharacteristically. Conveying this information alongside the findings from a patient's assessment may help caregivers appreciate and manage changes in their loved one. In addition, goals that may target certain aspects of social perception may be useful in the treatment plan of these deficits.

Limitations of study

This study attempted to contribute to better understanding about changes in social perception in people with MCI. There were a number of limitations identified in this study.

The issue of diagnosis and deciding on the most efficacious criteria is one of importance. We need a clear and consistent method of diagnosis of MCI. This may include a set of recommendations about neuropsychological tests, domains and number of subtests in each domain. Another limitation was that the current study did not have information on how patients in the clinical group were diagnosed. This could have helped to understand how this diagnosis is being used clinically. The MCI patients were included if any professional diagnosed them. This included a geriatrician, a clinical psychologist, a neuropsychologist, general physician or a psychiatrist. Not all patients from the clinical sample had been diagnosed using neuropsychological criteria. Additionally, a small portion of clinical participants who were contacted agreed to take part in the present study, possibly leading to a biased sample that may have potentially been more socially adept than those who did not participate.

Another limitation of the study was that information around changes in social perception was not sought from informants. Most of the informant assessments assessing behavioural change are focussed on dementia (Kaufer et al., 2000). The changes include psychotic features, affective changes, changes in motor behaviour such as agitation, pacing, aggression, apathy and other severe symptoms such as screaming, hygiene issues and mutism. Including questions about the changes noted in their loved one about their understanding of jokes, inability to understand subtleties in conversations and an increased vulnerability to believing lies might be useful.

The absence of informant measures for all participants was a limitation of this study. This was largely a logistic and a clinical challenge as many individuals lived on their own and getting an accurate picture of changes was difficult. Additional information around the impact of the deficits through interviews with significant others (caregivers or family members) or people who have known the participant for some time, even if they did not live with them or had regular contact with them, might have been helpful.

In this study, few people met criteria for multi domain MCI, particularly multi domain non-amnestic MCI. Research has shown that this subtype is more likely to progress to non-Alzheimer's type of dementia (Ferman et al., 2013; Yaffe et al., 2006). Additional research in the field may focus on including a larger sample of people with multi domain non-amnestic MCI and studying social perception in this cohort.

Strengths of the study

The research extends our knowledge on social perception in people with MCI. This is the first known study in New Zealand to have explored social perception in MCI. The key strengths of this study are the use of an ecologically valid measure to assess social perception, recruitment from both clinical and community samples, the use of a comprehensive neuropsychological battery of tests, evaluation of different classification criteria of MCI including the classification of subtypes, and the use of informant measures and social measures. It has also further described social functioning as well as social perception and examined the relationship between these factors.

This study is one of the first studies to have used the TASIT to assess social perception in people classified with MCI. To date, published research has largely used one or two sensory modalities (audio, visual, stories, etc.) to assess various aspects of social perception and tests used often lack information on psychometric properties. The TASIT is the only available test of social perception that is ecologically valid (McDonald et al., 2004). The current study contributes to the finding that the TASIT, despite it consisting of Australian actors, was used successfully in a New Zealand context and with older participants.

This study's strengths also lie in the large (96) number of participants recruited from the community. Further, considerable effort was placed on recruiting participants from a Māori background, resulting in 15% of the total sample who came from a Māori ethnicity. One of the biggest strengths of the current study is that considerable effort has been placed on the diagnosis of MCI. All participants were classified with MCI according to four different classification criteria available in research before selecting the most appropriate criteria. The

neuropsychological battery was selected by carefully examining literature and making sure there were at least three subtests in each domain, making the neuropsychological battery robust. The battery of tests included a variety of subtests that were both ecologically valid and well normed in the current population. Another strength of the current study is the inclusion of information regarding the subtypes of MCI. Subtypes of MCI not only give an overall view of the types of domains that are impaired but also provide information regarding the extent of impairment (single and multiple domain).

Finally, the current study was one of the first studies to contribute to the understanding about social functioning and social network that may be associated with social perception. The inclusion of measures that tapped into the frequency of social contact as well as the quality of social networks further adds to the knowledge that these are important aspects of social functioning.

Taken together, the current study provides valuable information that may be useful for future research in the area of identifying people with MCI who are at risk of developing a non-AD type dementia, particularly FTD, by including not only neuropsychological assessments but also social perception measures.

Suggestions for future research

Research into social perception in mild cognitive impairment is still in its infancy. Although there have been other tests (Funkiewiez et al., 2012), there are limited reliability and validity data available. There is a need for more robust social perception measures, which might prove useful in detecting people with early frontotemporal dementia or MCI.

The TASIT is the only test that incorporates valid cues that mimic real life situations. However, there are drawbacks in using this test with people with mild deficits. The TASIT has a low ceiling and is designed for the assessment of deficits. In the assessment of neuro-typical people who may be developing deficits in social perception, such as people with a risk of developing frontotemporal dementia, there is a need to make the test more difficult. This may provide us with more information around the normal range of variability as well as impairment in social perception (Funkiewiez et al., 2012; Sarazin, Dubois, de Souza, & Bertoux, 2012). Additionally, using the TASIT along with brain imaging methodologies would help provide information regarding the usefulness of considering social perception as a domain in a typical neuropsychological assessment.

To supplement the objective assessment of social perception, future research could focus on developing a questionnaire that may be sensitive to these changes and that can act as an adjunct to the TASIT. Including even two or three informant reported questions regarding these changes may provide additional important information and might possibly give rise to criteria for frontotemporal MCI that includes answering "yes" to a question regarding subtle changes in social perception. Currently, most of these instruments are targeted largely at moderate to severe changes in people with neurological, psychiatric and developmental disorders.

There is a need to collect information regarding social perception changes through the course of MCI, particularly the type of MCI that is likely to progress to frontotemporal dementia, which is the second most common type of dementia (Ballard et al., 2009). The age of onset in people with FTD may be as early as 40 years and is fast progressing. Frontotemporal dementia, particularly the behaviour variant FTD, is associated with changes in social perception (Funkiewiez et al.,

2012). Patients with FTD may have mood disturbances, anxiety and agitation. They may also show changes in personality and abnormal behavioural disturbances. These symptoms often lead to people with FTD being misdiagnosed with psychiatric conditions. Additionally, MCI that is likely to progress to FTD tends to be non-amnestic MCI (Ferman et al., 2013; Rosenberg et al., 2011; Yaffe et al., 2006) and people tend to show more executive functioning deficits in the early stages (Bott et al., 2014; Rascovsky et al., 2011). It may be beneficial for future research to focus on the addition of social perception assessments along with neuropsychological tests towards the early identification of frontotemporal dementia.

Conclusions

In this study, I sought to examine social perception in those with and without MCI. I explored social perception deficits in MCI and how this could be identified using the TASIT. I have also sought to examine the relationship between social perception and neuropsychological functioning in the hope that this may guide clinical practice as well as research.

The current thesis found no significant differences between MCI and non-MCI groups in their performance on the TASIT. Secondly, there was no significant association between social perception and neuropsychological functioning. The finding that the impairment on the TASIT did not differ between people with a diagnosis of MCI and those with no MCI further corroborated this. Future research could use the TASIT to possibly identify people who are at risk of developing frontotemporal dementia.

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Appendices

Appendix A Advertisement for first phase of recruitment of the Community Sample

Communication and Cognition in People 50 and above

I am a PhD candidate looking for participants to help me in studying communication in the ageing population.

If you are 50 and above, speak English and do not have any major health issues, I would love to hear from you. There would be a number of game type activities and video watching involved in the study.

You would get a $5 coffee voucher for every session as a thank you for your participation.

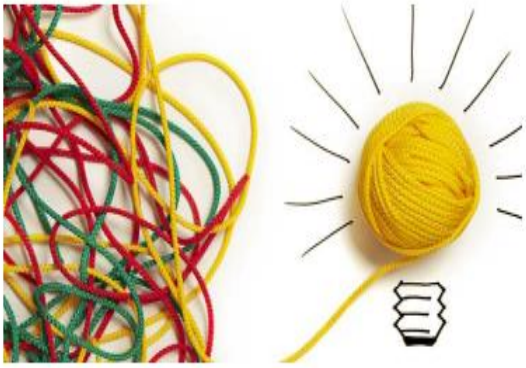
For more information, contact me, Sandhya Fernandez on 022 199 8650, or via email at **sandhyaf@waikato.ac.nz**

The project is conducted under the supervision of Dr. Nicola Starkey and Dr. Carrie Barber, School of Psychology, University of Waikato.

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Appendix B Advertisement for first phase of recruitment of the Community Sample

Are you or someone you care about experiencing any of these problems?



- Forgetting a lot?
- Not able to multitask as before?
- Trouble finding the right words?
- Forget things more often and not remember them later?
- Misplace things more than before?

If you have answered yes and for any of the above, are 50 years old or above and do not have any major health issues, we'd would love to hear from you!

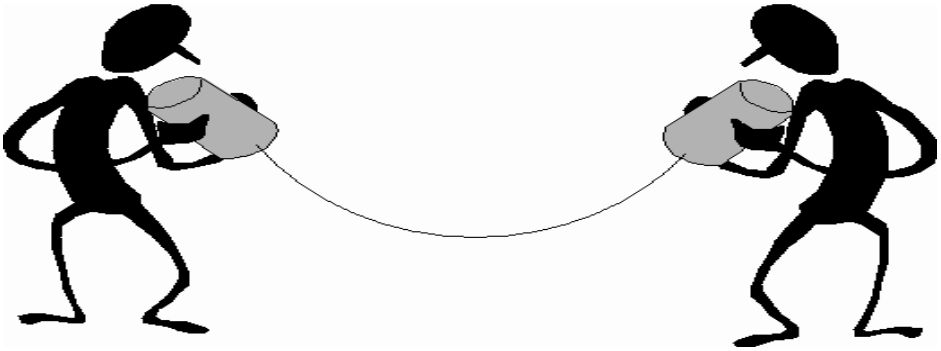
I am a PhD candidate looking for participants to help me in studying communication in the population over the age of 50.You will be asked to take part in a number of game type activities and video watching involved in the study.

You would get a $5 coffee voucher for every session as a thank you for your participation.

For more information, contact me, Sandhya Fernandez on 022 199 8650, or via email at fernandezsandhya@gmail.com

The project is conducted under the supervision of Dr. Nicola Starkey and Dr. Carrie Barber, School of Psychology, University of Waikato.

THE UNIVERSITY OF WAIKATO



Communication in people over the age of 50 with concerns about their memory

Information Sheet

What is the study about?

Social perception is the ability to accurately understand communication such as facial expressions, emotions and sarcasm. Social perception changes across the life span, particularly during childhood and adolescence. Currently there is little information about how social perception changes during adulthood, especially in older age groups

This study is being conducted by researchers at the University of Waikato and aims to test social perception among people over the age of 50.

Am I eligible to take part?

You are eligible to take part in this study if you are above 50 years of age, are not taking any medication that could impair your performance and have no history of dementia, stroke, head injury or substance abuse. You also should not be currently taking medication for any serious psychiatric illness.

What am I being asked to do?

If you agree to take part in this study, it will involve two to three sessions on different days within a span of a month. Each session should take around 1 and half hours. You will be asked to take part in a number of puzzle/game type tasks, which most people find enjoyable and stimulating. On one of the tests, you will be audio recorded for scoring purposes. We will also ask for some information about you and how you are feeling. As a thank you, you will get one $5 Momento café voucher per session with a maximum of $15 worth of vouchers. You can be seen in your own home, at your workplace or at the University of Waikato, whichever is most convenient for you.

What will happen to my information?

Be assured that no one will be able to identify you. All forms will be stored in a locked cabinet, in the School of Psychology at Waikato University and will be accessible only to the researcher and her supervisors. The researcher will conduct the analysis of the data. At the end of the study the paper-based forms will be destroyed. We will send a summary of our findings to the participants who have indicated they would like to receive this information, by email. The study has received ethical approval from the School of Psychology Ethics Committee

What can I expect from the researchers?

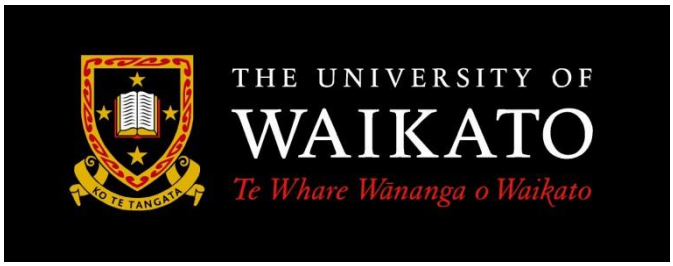
If you decide to participate in this project, the researchers will respect your right to:

- ask any questions of the researchers about the study at any time during participation;
- decline to answer any particular questions or carry out any of the tasks;
- withdraw from the study;
- provide information on the understanding that it is completely confidential to the researchers. All forms are identified by a code number, and are only seen by the researchers. It will not be possible to identify you in any articles produced from the study;
- be given a summary of the findings

Who can I speak with about my participation in this project?

If you, or anyone you know is interested in taking part in this research please contact **Ms. Sandhya Fernandez (PhD researcher) on ph 022 199 8650, or via email at fernandezsandhya@gmail.com**

Supervisors- Dr. Nicola Starkey, Dr. Carrie Barber



University of Waikato
Psychology Department

CONSENT FORM

PARTICIPANT'S COPY

Research Project:

Name of Researcher:

Name of Supervisor (if applicable):

I have received an information sheet about this research project or the researcher has explained the study to me. I have had the chance to ask any questions and discuss my participation with other people. Any questions have been answered to my satisfaction.

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Research and Ethics Committee ()

Participant's
Name:_____Signature:_____Date:_____

==========

University of Waikato
Psychology Department

CONSENT FORM

RESEARCHER'S COPY

Research Project:

Name of Researcher:

Name of Supervisor (if applicable):

I have received an information sheet about this research project or the researcher has explained the study to me. I have had the chance to ask any questions and discuss my participation with other people. Any questions have been answered to my satisfaction.

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Research and Ethics Committee.

Participant's Name: _____Signature:_____
Date:_____

Appendix D Information Sheet for Informants of Participants recruited from the Community Sample

Daily Activities and Mental Capacity in Ageing

Information Sheet-Informant/Caregiver

What is the study about?

Daily activities include the ability to look after oneself-being able to have a bath, cook a meal, and manage finance, to name a few. These activities are important as they make a person independent or dependent. As a part of the larger study on social perception in ageing, we want to know how people function- activity wise or in their capacity to think, remember and plan.

Social perception is the ability to accurately understand communication such as facial expressions, emotions and sarcasm. Social perception changes across the life span, particularly during childhood and adolescence. Currently there is little information about how social perception changes during adulthood, especially in older age groups.

As well as talking to the participant, we would also like to talk to someone who knows them well (you) about how they are doing and how they manage in their day-to day lives.

This study is being conducted by researchers at the University of Waikato and aims to test social perception among people over the age of 50.

What am I being asked to do?

If you agree to take part in this study, it will involve one session lasting about 20 minutes where you will be asked some questions about you (age, educational qualification, your relationship with the participant) and more questions about daily activities of the participant. You can be seen in your own home, at your workplace or at the University of Waikato, whichever is most convenient for you.

What will happen to my information?

Be assured that no one will be able to identify you. All forms will be stored in a locked cabinet, in the School of Psychology at Waikato University and will be accessible only to the researcher and her supervisors. The researcher will conduct the analysis of the data. At the end of the study the paper-based forms will be destroyed. We will send a summary of our findings to the participants who have indicated they would like to receive this information, by email. The study has received ethical approval from the School of Psychology Ethics Committee

What can I expect from the researchers?

If you decide to participate in this project, the researchers will respect your right to:

- ask any questions of the researchers about the study at any time during participation;
- decline to answer any particular questions or carry out any of the tasks;
- withdraw from the study;
- provide information on the understanding that it is completely confidential to the researchers. All forms are identified by a code number, and are only seen by the researchers. It will not be possible to identify you in any articles produced from the study;

- be given a summary of the findings

Who can I speak with about my participation in this project?

If you have any more questions, please contact **Ms. Sandhya Fernandez (PhD researcher) on ph 022 199 8650, or via email at fernandezsandhya@gmail.com .**

Supervisors- Dr. Nicola Starkey, Dr. Carrie Barber

Appendix E Letter to Potential Participants from the District Health Boards

Date:

Dear _____,

Researchers from the School of Psychology, University of Waikato are conducting a study of communication in people with the diagnosis of mild cognitive impairment. As a person with a provisional diagnosis of mild cognitive impairment, we would like to invite you take part in research project. The title of the project is:

Social Perception and Neuropsychological Deficits in Mild Cognitive Impairment

This research will involve you meeting the researcher at your home, office or at the researcher's office on one day or on two different occasions and completing some questionnaires and carryout some game-like exercises.

An information sheet has been enclosed and the researcher will contact you to discuss your potential involvement in the study. You will have an opportunity to ask any questions before you consent to participate. Please do not hesitate to contact the research team if you have any questions about this project.

Many thanks for your time.

Kind regards,

Ms. Sandhya Isabella Fernandez

PhD Student and Clinical Psychologist

University of Waikato

fernandezsandhya@gmail.com

0221998650

This study has received Ethical Approval from the Health and Disability Ethics Committee (Ref 16/NTA/58)

Appendix F Participant Information Sheet and Consent Form for the Clinical Sample

Project Title: Social Perception and Neuropsychological Deficits in Mild Cognitive Impairment

Researchers: Sandhya Fernandez, PhD student and Clinical Psychologist, University of Waikato

Nicola Starkey, Associate Professor and Carrie Barber, Senior Lecturer and Director of Clinical Psychology, University of Waikato.

We would like to invite you to participate in this project looking at social perception and neuropsychological deficits in mild cognitive impairment. This project is being run as a part of my PhD study at the School of Psychology, University of Waikato.

Social perception is the ability to accurately understand communication such as facial expressions, emotions and sarcasm. Social perception changes across the life span, particularly during childhood and adolescence. Currently there is little information about how social perception changes during adulthood, especially in older age groups

This Participant Information Sheet will help you decide if you'd like to take part. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of both the Participant Information Sheet and the Consent Form to keep.

This document is 5 pages long, including the Consent Form. Please make sure you have read and understood all the pages.

WHAT WILL I HAVE TO DO?

If you agree to take part in this study, it will involve one or two sessions on different days within a span of a month. Each session should take around 1 and half hours. You will be asked to take part in a number of puzzle/game type tasks, which most people find enjoyable and stimulating. These tests will examine your thinking, problem-solving and reasoning abilities. On one of the tests, you will be audio recorded for scoring purposes. We will also ask for some information about you and how you are feeling.

You can be seen in your own home, at your workplace or at the researcher's office at the University of Waikato, whichever is most convenient for you.

Information about your medical history will be obtained from your medical file. With your consent we will also send a questionnaire to a family member to complete.

As recognition of your time and participation you will receive a $30 supermarket voucher at the end of the assessments.

WHAT ARE THE POSSIBLE BENEFITS AND RISKS OF THIS PROJECT?

Your test results will be sent to your clinician at the Bay of Plenty hospital with your consent. There are no potential risks to participating in the study.

WHAT WOULD EXCLUDE ME FROM PARTICIPATING IN THIS PROJECT?

Exclusion criteria for this project include:

1. A diagnosis of dementia
2. Regular use of illicit substances
3. History of neurological conditions including stroke, head injury or other conditions
4. Taking medication for a serious psychiatric illness

This is to ensure that the results on the tests and exercises are not influenced by other factors.

WHAT ARE MY RIGHTS?

Whether or not you take part is your choice. If you don't want to take part, you don't have to give a reason, and it won't affect the care you receive. If you do want to take part now, but change your mind later, you can pull out of the study at any time. The information that is collected from you will still be part of the research. A summary of the individual findings can be provided if you request this.

The information collected will be stored confidentially. The database will be stored on the University of Waikato computer system and the paper assessments will be stored securely in locked drawers, the key to which will be kept with the principal investigator. It will be accessed by a password by the researcher collecting the data. The data will be held for a maximum of 7 years and may be used in future research and the principal investigator will be responsible for this.

WHAT HAPPENS AFTER THE STUDY?

At the end of the study, a summary sheet with the general research findings will be sent to you directly within a year of the completion of the study.

WHO CAN I CONTACT?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Ms. Sandhya Fernandez

PhD Student and Clinical Psychologist

Private Bag 3105, University of Waikato, Hamilton

0221998650

fernandezsandhya@gmail.com

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050

Fax: 0800 2 SUPPORT (0800 2787 7678)

Email: advocacy@hdc.org.nz

For Māori health support please contact:

Regional Māori Health Services in Tauranga is located in the west wing of Silver Birch House. This site can be accessed via Clark street gate 4 with easy access to car parks directly adjacent to Silver Birch House. Phone: 07 579 8000

Regional Māori Health Services in Whakatāne site is located in a dedicated building between Te Toki Maurere and the clinical school. This site can be

accessed via Garaway Street gate 5, with limited car parking directly outside this site; however, there is easy access to clearly sign posted public car-parks. Phone: 07 306 0999

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS

Email: hdecs@moh.govt.nz

FINALLY

This study has received Ethical Approval from the Health and Disability Ethics Committee (Ref 16/NTA/58)

Consent Form

Social Perception and Neuropsychological Deficits in Mild Cognitive Impairment

Sandhya Fernandez, PhD Student and Clinical Psychologist, University of Waikato, Nicola Starkey, Associate Professor and Carrie Barber, Senior Lecturer and Director of Clinical Psychology, University of Waikato.

I have read and I understand the Participant Information Sheet.	No ☐
I have been given sufficient time to consider whether or not to participate in this study.	No ☐
I have had the opportunity to use a legal representative, whanau/ family support or a friend to help me ask questions and understand the study.	No ☐
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	No ☐
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my medical care.	No ☐
I consent to the research staff collecting and processing my information, including information about my health.	No ☐
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	No ☐
I agree to an approved auditor appointed by the New Zealand Health and Disability Ethic Committees, or any relevant regulatory	No ☐

authority or their approved representative reviewing my relevant medical records for the sole purpose of checking the accuracy of the information recorded for the study.		
I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.		No ☐
I understand that my data will be kept indefinitely and the data can be used in future research, including this consent form.		No ☐
I understand my response to the Test of Premorbid Functioning (TOPF) will be audio-recorded		No ☐
I would like my scores for the cognitive and social perception (TASIT) tests to be attached to my medical file.	Yes ☐	No ☐
I know who to contact if I have any questions about the study in general.		No ☐
I understand my responsibilities as a study participant.		No ☐
I wish to receive a summary of my individual results from the study.	Yes ☐	No ☐

Name:

_____

Address:

_____

_____

Declaration by participant:

I hereby consent to take part in this study.

Participant's name:

Signature: Date:

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name:

Signature: Date:

Appendix G Information Sheet for Informants of Participants from the Clinical Sample

Information Sheet for Informant/Caregiver

Project Title: Social Perception and Neuropsychological Deficits in Mild Cognitive Impairment. Daily Activities and Mental Capacity in people with Mild Cognitive Impairment.

Researchers: Sandhya Fernandez, PhD Student and Clinical Psychologist, University of Waikato, Nicola Starkey, Associate Professor and Carrie Barber, Senior Lecturer and Director of Clinical Psychology, University of Waikato

You are receiving this information sheet because your family member/friend _____ has consented to participate in this research project looking at social perception and neuropsychological deficits in mild cognitive impairment. As part of the project we are wanting to get caregiver's perspectives on daily activities and mental capacity of the participant.

This project is being run as a part of my PhD studies at the School of Psychology, University of Waikato.

Daily activities include the ability to look after oneself-being able to have a bath, cook a meal, and manage finance, to name a few. These activities are important as they make a person independent or dependent. As a part of the larger study on social perception in mild cognitive impairment, we want to know how people function-activity wise or in their capacity to think, remember and plan.

Social perception is the ability to accurately understand communication such as facial expressions, emotions and sarcasm. Social perception changes across the life

span, particularly during childhood and adolescence. Currently there is little information about how social perception changes during adulthood, especially in older age groups.

As well as talking to the participant, we would also like to talk to someone who knows them well (you) about how they are doing and how they manage in their day-to day lives.

If you agree to take part in this study, it will involve one session lasting about 20 minutes where you will be asked some questions about you (age, educational qualification, your relationship with the participant) and more questions about daily activities of the participant. You can be seen in your own home, at your workplace or at the University of Waikato, whichever is most convenient for you.

If you choose to have these questionnaires posted to you, a return self-addressed envelope with the questionnaires will be sent for you to send back.

The researcher will call you at a mutually convenient time and explain the questionnaires to you.

At the end of the study, a summary of the general research findings will be available on the Bay of Plenty District Health Board website.

WHO CAN I CONTACT?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Ms. Sandhya fernandez, PhD Student and Clinical Psychologist

Private Bag 3105, University of Waikato, Hamilton

0221998650

Phone: 0221998650 *Email: fernandezsandhya@gmail.com*

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You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS Email: hdecs@moh.govt.nz

This study has received Ethical Approval from the Health and Disability Ethics Committee (Ref 16/NTA/58)

Appendix H Demographic Questionnaire

Ask the following questions and record the answers.

Q#	Question	
H1.1.1	Could you tell me your current marriage or partnership status? (Tick any one)	Legally married (1) Civil union/de facto/partnered/opposite sex relationship (2) Divorced or permanently separated from my legal husband or wife (3) Widow or widower (4) Single (5)
H1.1.2	Which ethnic group do you identify yourself to the most? (Tick any one)	NZ European (1) Māori (2) Samoan (3) Chinese (4) Indian (5) Tongan (6) Other (Specify here_____)
H1.1.3	Are you right or left handed? (Tick any one)	Right (1) Left (2)

H1.1.4	What is your highest secondary school qualification?	
H1.1.5	What is your highest qualification and the main subject?	
H1.1.6	Do you currently work?	Yes (1) No (2)
H1.1.7	If yes, how many hours in a week do you work?	
H 1.1.8	If no, how long has it been since you retired?	
H1.2.1	Do you have any significant problems with your hearing? If yes, specify.	Yes (1)_____ No (2)
H1.2.2	Do you have any significant problems with your sight? If yes, specify.	Yes (1) _____ No (2)
H 1.2.3	Do you have any significant problems with	Yes (1) _____ No (2)

	your hand mobility? If yes, specify.	
H1.2.4	Now I am going to ask you about any medical condition. Has a doctor or medical person ever told you that you have any of the following in the last 2 YEARS?	Previous head injury resulting in loss of consciousness (1) Previous concussion (2) Stroke(3) Alzheimer's disease (4) Dementia other than Alzheimer's disease (5) Developmental disability (6) Multiple sclerosis (7) Parkinson's disease (8) Epilepsy/seizures (9) Any other serious medical condition (10)
H1.2.5	Do you suffer from any mental health difficulty (psychiatric illness such as depression, anxiety disorder, schizophrenia, paranoia)	Depression (1) Anxiety disorder (2) PTSD (3) Schizophrenia (4) Obsessive Compulsive disorder (5)

		Other, please specify_____
H 1.2.6	Would you like a summary of the findings of the group at the end of the study? Yes- Please indicate your email address or your home address where you would like to receive the same.	

Appendix I Background Information

Q#	**Question**	
H 5.1	How many people live with you in the same household at present? Who are they?	My legal husband or wife (1) My partner or de facto, boyfriend or girlfriend (2) My son(s) and/or daughter(s) (3) My parent(s) and/or parent(s)-in-law (4) My sister(s) and/or brother(s) (5) My flatmate(s) (6) My grandchild(ren) (7) My friend(s) (8) My boarder(s) (9) Pet (s) (10) Other (s) (please specify) (11) None of the above-I live alone (12)

H 5.2	How many different medications do you take everyday?	None (1) 1 to 2 (2) 3 to 5 (3) 6 to 7 (4) 8 or more (5)
H 5.3	Do you take any of these medications at least once a week? Circle ONE number per row. If respondent is uncertain about any you can refer to the separate medications information sheet	Sedatives or sleeping medicines (e.g. Apo-Zopiclone, Hypam, Ox-Pam, ormison, Nitrados)No (1), Yes (2), Don't know (3) Anti-psychotic or anti-anxiety medicines (Zyprexa, Ridal) No (1), Yes (2), Don't know (3) Narcotic medications (Codeine Phosphate Tabs, M-Elson, Oxynorm, Oxycontin, Tramal) No (1), Yes (2), Don't know (3) Muscle relaxants (Pro-pam) No (1), Yes (2), Don't know (3)

		Erectile dysfunction medicines (Viagra, Cialis, Avigra, Vedafil, Silagra) No (1), Yes (2), Don't know (3)
H 5.4	Do you now take any of these medications every day or almost everyday? Circle one number per row. If respondent is uncertain about any you can refer to the separate medications information sheet	Ulcer and stomach medication (e.g.Famox, Losec, Dr. Reddys Pantoprazole, Somac, Ranitidine Arrow) No (1), Yes (2), Don't know (3) Arthritis and pain medicines (e.g. Apo-Allopurinol, Apo-Diclo, I-Profen, Panadol, Celebrex) No (1), Yes (2), Don't know (3) Diabetes medications (e.g. Apo-Gliclazide, Minidiab, Arrow Metformin) No (1), Yes (2), Don't know (3) Blood pressure medicines (e.g. Betaloc, Atacand, Dilzem, Felo, Apo-Prazo)

		No (1), Yes (2), Don't know (3) Nitrates (e.g. Duride Tabs, Corangin, Nitrolingual pump spray) No (1), Yes (2), Don't know (3) Other medicines of the heart (e.g. Cordarone X, Lanoxin, Tambocor, Duirin) No (1), Yes (2), Don't know (3) Anticoagulants (e.g. warfarin) No (1), Yes (2), Don't know (3) Seizure medicines (e.g. Tegretol, Arrow-Lamotrigine, Phenobarbitone PSM, Dilantin, Epilim) No (1), Yes (2), Don't know (3) Anti-Depressant medications (e.g. Amitrip, Arrow-Citalopram, Anten, Fluox, Loxamine) No (1), Yes (2), Don't know (3)

		Non-sedating, non-drowsy antihistamines (e.g. Razene, Telfast) No (1), Yes (2), Don't know (3) Sedating, sleep inducing antihistamines (e.g. Phenergan) No (1), Yes (2), Don't know (3) Cholesterol lowering medicines (e.g. Arrow-Simva, Lipitor, Bezalip) No (1), Yes (2), Don't know (3) Bladder medicines (e.g. Apo-Oxybutinin, Apo-Prazo, Flomax, Hytrin) No (1), Yes (2), Don't know (3)
H 5.5.1	Do you have a current driver's license?	Yes (1) No (2)
H 5.5.2	How often do you drive?	Never (1) Less than once a month (2)

		At least once a month but less than weekly (3) At least once a week but less than daily (4) Daily or almost daily (5)
H 5.5.3	If you currently drive, have you ever considered reducing the amount that you drive or stopping altogether?	Yes (1) No (2)
H 5.5.4	If you have considered stopping driving altogether OR you have stopped driving OR you have never driven: what was the MAIN reason for this?	Family/friends recommended that I stop (1) Licensing or license renewal problems (2) Changes due to ageing (3) I don't need a car (4) Friends drive me if needed (5) Health reasons make driving difficult (6) My GP/doctor recommended that I stop (7)

		Driving is unpleasant (8) I feel anxious when driving (9) My spouse/partner drives me if needed (10) Driving is expensive/car costs a lot (11) Other reason? (please specify)_____

H 5.6	*We would like to know whether you participate in recreational activities. Please indicate if you have never, once a year, twice a year, 4 times a year, monthly or yearly participated in any of what I will read out to you.*	
H 5.6.1	Have you…..	Never (1) Once a year (2)

	Been a spectator at a sports event	Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.6.2	Have you….. Gone to a concert, movie, play or other cultural event	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.6.3	Have you….. Gone to a restaurant, café, pub or bar	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.6.4	Have you….. Participated in an outdoor activity (walking, cycling, etc.)	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.6.5	Have you….. Gone to a library or museum	Never (1) Once a year (2) Twice a year (3)

		Four times a year (4) Monthly (5) Weekly (6)
H 5.6.6	Have you….. Gone to a barbeque, hangi, or similar event away from your home	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.7	*These are questions about your participation in organizations and clubs. Please indicate below how often you attend each organization or club.*	
H 5.7.1	Sports club	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)

H 5.7.2	Community or service organizations that help people	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.7.3	Political party, trade union, professional association, or business organization	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.7.4	Religious, church or other spiritual organization	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.7.5	Hobby, leisure-time or arts association/group	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)

H 5.7.6	Other cultural/ethnic group that encourages cultural/ethnic knowledge, traditions or arts	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)
H 5.7.7	Any other club, lodge, group or similar organization (please specify)	Never (1) Once a year (2) Twice a year (3) Four times a year (4) Monthly (5) Weekly (6)

Appendix J Descriptive statistics of the community recruited sample and the MCI diagnosed DHB recruited sample

Demographic details	**Community sample (96)**		**DHB recruited MCI (21)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*
Age	62.74 (8.12)	50-83	72.24 (3.1)	0-17
Gender	F=71.9%		F=47.6%	
Education (years completed)	12.97 (3.1)	0-17	10.83 (3.5)	0-14
MoCA	28.8 (1.29)	25-30	23.86 (3.75)	14-28
GDS	0.96 (1.1)	0-4	1.9 (1.76)	0-7
AUDIT	2.77 (1.75)	0-8	2.38 (2.42)	0-8
	Mean T score (SD)	*T score range*	*Mean T score (SD)*	*T score range*
Memory				
Logical memory I	53.2 (8.02)	30-70	38.5 (11.9)	20-60
One back test (Cogstate)	50.6 (8.5)	34.6-80.21	59.2 (11.67)	36.61-82.59
Two back test (Cogstate)	46.1 (8.8)	23.70-68.34	59.8 (13.7)	41.5-82.7
One card learning (Cogstate)	49.1 (7.2)	31.77-68.81	41.5 (6.8)	28.54-57.39
International Shopping List Recall (Cogstate)	55.9 (7.6)	38.68-67.42	31.74 (13.1)	10.19-49.08
Memory Domain Score	51.04 (3.3)	41.96-59.87	46.2 (6.1)	32.1-55.6
Language				
Letter fluency (DKEFS)	61.9 (12.02)	30-80	50.6 (12)	26.67-80
Category fluency (DKEFS)	63.1 (11.7)	40-80	44.2 (10.4)	20-60
Category Switching (DKEFS)				
Colour naming (DKEFS)	53.8 (7.1)	33.33-66.67	47.3 (10.8)	20-63.33
Word reading (DKEFS)	55.2 (7.01)	30-66.67	49.5 (11.11)	26.67-70
Language Domain Score	58.9 (6.87)	38.67-74.00	46.8 (7.73)	24.00-59.33
Executive functioning				

Number sequencing (DKEFS)	56.07 (10.1)	20-70	50.9 (11.5)	20-66.67
Letter sequencing (DKEFS)	57.96 (7.5)	30-66.67	50.15 (10.8)	20-60
Number-letter sequencing (DKEFS)	57.2 (7.1)	33.33-70	41.6 (14.6)	20-63.33
Colour-word interference (DKEFS)	54.8 (8.7)	30-66.67	46.98 (10.4)	20-60
Colour-word interference switching (DKEFS)	55.9 (7.97)	20-70	46.03 (16.21)	20-70
Executive Functioning Domain Score	56.4 (6.4)	34.67-66.67	47.1 (10.2)	20-58
Visuospatial Functioning				
ROCFT, Copy	45.8 (11.6)	1.19-59.85	35.09 (17.3)	0.69-60.02
GMCT (Cogstate)	44.9 (9.49)	22.09-75.21	52.9 (10.04)	35.65-75.27
Visual scanning (DKEFS)	56.1 (6.6)	36.67-66.67	53.5 (7.1)	40-66.67
Visuospatial Functioning Domain Score	48.97 (5.2)	33.75-58.08	47.2 (6.8)	29.10-57.02

Note. SD= Standard deviation; MCI=Mild Cognitive Impairment; MoCA= Montreal Cognitive Assessment; GDS= Geriatric Depression Scale; AUDIT=Alcohol Use Disorders Identification Test; TOPF= The Test of Premorbid Functioning

Appendix K Means and standard deviations on neuropsychological measures of community participants who met the MCI diagnostic criteria according to four different classification criteria of MCI.

Demographic details	**Liberal (78)**		**Conventional (47)**		**Comprehensive (25)**		**Conservative (5)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*
Age	63.19 (8)	50-83	63.53 (8.1)	51-79	66 (7.2)	53-79	63 (10.2)	53-75
Gender	F=70.5%		F= 76.6%		F=64%		F=80%	
Education (y)	13.03 (3)	0-17	13 (2.8)	0-17	12.32 (3.7)	0-17	12.4 (1.6)	10-14
MoCA	28.71 (1.3)	25-30	28.5 (1.3)	25-30	28.16 (1.5)	25-30	27.8 (1.64)	26-30
GDS	0.96 (1.2)	0-4	1.06 (1.1)	0-4	1.2 (1.29)	0-4	2.4 (1.5)	1-4
AUDIT	2.74 (1.69)	0-7	2.57 (1.6)	0-7	2.8 (1.68)	0-6	2.6 (1.9)	1-6
	Mean T score (SD)	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*
Memory Domain Score	50.7 (3.4)	41.96-59.87	50.6 (3.5)	43.82-59.87	49.6 (4.04)	41.96-59.87	52.74 (4.3)	49.26-58.07
Language Domain Score	58.7 (7.1)	38.67-74	58.1 (7.4)	38.67-70.67	57.04 (8.2)	38.67-72.67	54.66 (11.8)	38.67-70.00
Executive Functioning Domain Score	55.9 (6.8)	34.67-65.33	54.53 (7.6)	34.67-65.33	51.38 (8.67)	34.67-64.00	47.7 (11.8)	34.67-62.00
Visuospatial Functioning Domain Score	48.1 (5.2)	33.74-58.08	46.5 (5.3)	33.74-55.35	46.6 (6.03)	33.74-55.35	49.18 (4.6)	43.82-54.83

Appendix L Means and standard deviations on neuropsychological measures of DHB recruited participants who met the MCI diagnostic criteria according to four different classification criteria of MCI.

Demographic details	**Liberal (21)**		**Conventional (21)**		**Comprehensive (16)**		**Conservative (10)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*
Age	72.24 (10.4)	46-88	72.24 (10.4)	46-88	71.6 (11.1)	46-88	70.7 (12.4)	46-88
Gender	F= 47.6%		F=47.6%		F=43.8%		F=20%	
Education (y)	10.83 (3.5)	0-14	10.83 (3.5)	0-14	11.1 (3.3)	0-14	11.8 (1.5)	10-14
MoCA	23.9 (3.7)	14-28	23.9 (3.7)	14-28	22.9 (3.8)	14-28	21 (3.5)	14-27
GDS	1.9 (1.8)	0-7	1.9 (1.8)	0-7	2 (1.9)	0-7	2.10 (2.4)	0-7
AUDIT	2.4 (2.42)	0-8	2.4 (2.42)	0-8	2.3 (2.5)	0-8	2 (2.6)	0-8
	Mean T score (SD)	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*
Memory Domain Score	46.2 (6.1)	32.05-55.6	46.2 (6.1)	32.05-55.62	44.9 (6.2)	32.05-55.6	42.6 (6.2)	32.05-51.52
Language Domain Score	46.8 (7.7)	24-59.33	46.8 (7.7)	24-59.3	45.6 (8.5)	24-59.33	42.33 (8.6)	24-52
Executive Functioning Domain Score	47.14 (10.2)	20-58	47.14 (10.2)	20-58	45.1 (10.8)	20-58	42.13 (12.6)	20-58
Visuospatial Functioning Domain Score	47.2 (6.8)	29.10-57.02	47.2 (6.8)	29.10-57.02	47.5 (6.5)	29.10-56.8	46.7 (7.7)	29.10-56.8

Note. SD= Standard deviation; MCI=Mild Cognitive Impairment; MoCA= Montreal Cognitive Assessment; GDS= Geriatric Depression Scale; AUDIT=Alcohol Use Disorders Identification Test; TOPF= The Test of Premorbid Functioning

Appendix M Means and standard deviations on main measures of all participants who met the MCI diagnostic criteria according to four different classification criteria of MCI

Demographic details	**Liberal (99)**		**Conventional (68)**		**Comprehensive (41)**		**Conservative (15)**	
	Mean (SD)	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*	*Mean (SD)*	*Range*
Age	65.11 (9.3)	46-88	66.22 (9.7)	46-88	68.2 (9.2)	46-88	68.2 (11.9)	46-88
Gender	F=65.7%		F=67.6%		F=56.1%		F=40%	
Education (y)	12.6 (3.2)	0-17	12.33 (3.2)	0-17	11.8 (3.5)	0-17	12 (1.5)	10-14
MoCA	27.7 (2.9)	14-30	27.10 (3.2)	14-30	26.12 (3.7)	14-30	23.3 (4.4)	14-30
GDS	1.16 (1.4)	0-7	1.32 (1.4)	0-7	1.51 (1.6)	0-7	2.20 (2.1)	0-7
AUDIT	2.67 (1.9)	0-8	2.51 (1.9)	0-8	2.6 (2.03)	0-8	2.20 (2.4)	0-8
	Mean T score (SD)	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*	*Mean T score (SD)*	*T score range*
Memory Domain Score	49.75 (4.5)	32.05-59.9	49.24 (4.9)	32.05-59.9	47.8 (5.45)	32.05-59.9	45.9 (7.4)	32.05-58.1
Language Domain Score	56.21 (8.7)	24-74	54.61 (9.1)	24-70.7	52.6 (9.9)	24-72.7	46.44 (11.1)	24-70
Executive Functioning Domain Score	54.1 (8.4)	20-65.33	52.3 (9.1)	20-65.3	48.9 (9.9)	20-64	44 (12.2)	20-62
Visuospatial Functioning Domain Score	47.9 (5.6)	29.10-58.1	46.8 (5.8)	29.10-57.02	46.9 (6.2)	29.10-56.8	47.51 (6.8)	29.10-56.8

Note. SD= Standard deviation; MCI=Mild Cognitive Impairment; MoCA= Montreal Cognitive Assessment; GDS= Geriatric Depression Scale; AUDIT=Alcohol Use Disorders Identification Test; TOPF= The Test of Premorbid Functioning