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SOCIAL COGNITION ACROSS AGEING: EXPLORING SOCIAL COGNITION PERFORMANCE IN INDIVIDUALS WITH AND WITHOUT RISK OF DEMENTIA

VOLUME 1

Dissertação de Mestrado no âmbito do Mestrado de Neuropsicologia Clínica: Avaliação e Intervenção orientada pela Professora Doutora Ana Rita Sousa Silva e apresentada Faculdade de Psicologia e Ciências da Educação, Universidade de Coimbra

September 2023

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University of Coimbra

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Acknowledgments

É uma lista extensa, mas aqueles a quem agradeço tudo o que tenho e tudo o que sou aos meus pais. Ao meu irmão, porque foi ele que disse “é agora ou nunca” e à minha cunhada que me faz rir quando me estou a sentir um zombie. À minha avó, que está sempre a perguntar quando é que eu acabo “isto”. É agora, vó.

Quero estender o meu agradecimento aos professores do Mestrado de “Neuropsicologia Clínica: Avaliação e Reabilitação” que são todos excelentes, mas em especial à minha orientadora, Professora Ana Rita Silva, pela paciência, simpatia e sugestões que me ajudaram muito a ultrapassar este último desafio.

Agradeço às minhas amigas e amigos, àqueles que já vêm de antes e aos que chegaram durante este percurso. À Bea, Filipa, Carolina, Ana Rita, Cátia, Mariana, Sofia. Acredito que se for de verdade podemos seguir caminhos diferentes mas quando voltarmos a falar tudo será como era. Quero fazer um parenteses especial para a Filipa e a Maria, sinto que só sobrevivi porque num certo Portal compartilhámos inseguranças e nos ajudámos umas às outras. Obrigada.

Um obrigada também a mim, que isto não foi fácil.

Abstract

Introduction: Social cognition includes processes (e.g., social perception, mirror neurons, and theory of mind) that are crucial for adapting to social contexts. According to the literature, a strong profile of social cognition has been associated with a better quality of life and social functioning. However, numerous studies suggest that both general cognition and social cognition tend to decline with age. Additionally, psychosocial factors can impact social cognition, as well as the risk of dementia. Thus, it is important to investigate social cognition in the context of dementia prevention to comprehend the pattern of social cognition decline in individuals at risk of developing dementia. This will provide valuable information to enhance the development of social cognition assessment protocols and dementia intervention and prevention programs.

Objective: This exploratory study aims to investigate the performance of social cognition in cognitively healthy older adults at increased risk of dementia and its relationship with sociodemographic variables and perceived risk factors.

Methodology: A quasi-experimental exploratory study was conducted, recruiting a convenience sample of 111 adults aged between 55 and 75 years. Participants underwent a comprehensive neuropsychological assessment protocol. To assess social cognition, the Reading the Mind in the Eyes Test (RMET) and the Social Norms Questionnaire (SNQ-22) were used. Additionally, measures of social isolation and social support were incorporated. The sample was divided into two groups based on the "Lifestyle for Brain Health" (LIBRA) score: low and high dementia risk.

Results: The results of this study indicate that the understanding of social norms decreases with age, while the capacity for affective Theory of Mind (ToM) remains relatively stable. Another finding relates to the significantly lower performance in affective ToM in individuals at higher risk of dementia, explaining 3% of this risk dimension. Depressive symptoms, along with affective ToM, emerged as the best explanatory model for dementia risk when analysing various psychosocial risk factors, collectively accounting for approximately 11% of this risk. Furthermore, it was found that a greater perception of social support is positively correlated with affective ToM ToM, with no evidence of any relationship between social isolation and this aspect of social cognition.

Conclusions: This study emphasizes the importance of integrating social cognition and risk variables such as social support and depressive symptoms in both neuropsychological assessment and future interventions related to dementia prevention. However, further research is necessary to delve into the relationship between various dimensions of social cognition and dementia risk.

Keywords: Social cognition, theory of mind, social norms, risk of dementia, neuropsychological assessment

Resumo

Enquadramento: A cognição social inclui processos (e.g. perceção social, neurónios espelho e a teoria da mente) que são cruciais para a adaptação em contextos sociais. Na literatura, ter um perfil de cognição social forte tem sido associado a melhor qualidade de vida e funcionamento social. Contudo, vários estudos indicam que, com a idade, a cognição geral e a cognição social tendem a diminuir. Além disso, fatores psicossociais podem afetar tanto a cognição social quanto o risco de demência. Portanto, é fundamental investigar a cognição social no âmbito da prevenção da demência, para perceber o padrão de declínio da cognição social em pessoas em risco de desenvolver demência e, simultaneamente, fornecer informação para melhorar o desenvolvimento de protocolos de avaliação da cognição social e programas de intervenção e prevenção da demência.

Objetivos: O presente estudo exploratório tem como objetivo investigar o desempenho de cognição social em adultos idosos cognitivamente saudáveis com risco acrescido de demência e a relação desse desempenho com variáveis sociodemográficas e com variáveis de risco percebido.

Metodologia: Foi desenvolvido um estudo quasi-experimental de natureza exploratória, tendo sido recrutada uma amostra de conveniência de 111 adultos, com idades compreendidas entre 55 e 75 anos. Os participantes realizaram um protocolo compreensivo de avaliação neuropsicológica. Para avaliar a cognição social foram utilizados o teste Reading the Mind in the Eyes Test (RMET) e o Questionário de Normas Sociais (QNS-22). Adicionalmente, foram incorporadas medidas de isolamento e suporte social. A amostra foi dividida em dois grupos com base na pontuação do "LIfestyle for BRAin Health" (LIBRA): baixo e alto risco de demência.

Resultados: Foi possível verificar que compreensão das normas sociais diminui com a idade, enquanto a capacidade da Teoria da Mente (TM) afetiva permanece relativamente estável. Outro resultado encontrado diz respeito ao desempenho na TM afetiva ser significativamente mais baixo em indivíduos com risco mais elevado de demência, explicando esta dimensão da cognição 3% desse risco. A sintomatologia depressiva juntamente com a TM afetiva, revelou-se o modelo melhor explicativo do risco de demência quando analisados os vários fatores de risco psicossociais, explicando em conjunto aproximadamente 11% desse risco. Além disso, constatou-se que uma maior

perceção de apoio social se encontra positivamente correlacionada TM afetiva, não tendo o isolamento social mostrado qualquer relação com esta dimensão da cognição social.
Conclusões: Com o presente estudo foi possível realçar a importância de integrar a cognição social e variáveis de risco, como apoio social e sintomatologia depressiva, tanto na avaliação neuropsicológica como em futuras intervenções ligadas à prevenção do risco de demência. São, no entanto, necessários mais estudos para aprofundar a relação das várias dimensões da cognição social com o risco de demência.

Palavras-chave: Cognição social, teoria da mente, normas sociais, risco de demência, avaliação neuropsicológica.

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Introduction

The ageing process is associated with structural and functional changes in overall cognitive performance, including those related to social cognition processes (Hughes et al., 2019), which could lead the individual to commit errors or failures in social perception, and in the ability to understand mental states or emotions (Theory of Mind), or lead to a lack of or excessive empathy and inappropriate social behaviour (Henry et al, 2023; Porcelli et al., 2019).

Social cognition enables adaptive and flexible social behaviour within one's environment (Roheger et al., 2022b). A decline in social cognition performance can increase the risk of individual isolation, which can have serious consequences, as social isolation negatively impacts an individual's life expectancy and quality of life (Arioli et al., 2018; Evans et al., 2019; Haslam et al., 2017; Hughes et al., 2019). As social beings, interaction with others and the presence of robust social networks are crucial for the development and preservation of social cognition (Lewis et al., 2011; Pillemer et al., 2016) and are known to play a protective role against cognitive decline (Pillemer et al., 2016). Considering that individuals live in a dynamic environment that influences both social cognition and modifiable risk factors for dementia development (Cacioppo & Hawkley, 2009; Morese & Palermo, 2022), the present exploratory study aims to explore the social cognition profile of individuals at risk of dementia but still cognitively healthy. Furthermore, it seeks to understand whether this profile can predict the risk of dementia. Understanding this relationship is important for providing insights to design intervention programs (Lucena, 2020).

The current master's thesis is organised into five chapters. The first chapter includes the Conceptual Framework and begins with a literature review of the study variables. This chapter is divided into ten subchapters, introducing the theme of social cognition and its significance in dementia prevention. The second chapter encompasses the Methodology, where study objectives and hypotheses are defined. Additionally, it provides detailed descriptions of sample collection procedures, inclusion and exclusion criteria, the assessment protocol, and the statistical methods used for data analysis. The third chapter presents the Results, starting with a description of the sociodemographic characteristics of the final sample, followed by the analysis of sub-samples consisting of low and high-dementia risk groups. Subsequently, hypothesis tests previously formulated

are conducted. The fourth chapter encompasses the Discussion of the obtained results, situating them within the context of the reviewed literature, as well as its limitations and suggestions for future studies. The fifth and last chapter includes the final Conclusion which highlights the results and gives clinical implications.

I. Conceptual Framework

1.1. Social Cognition

Social Cognition is an umbrella term that refers to a set of cognitive processes, implicit in social behaviour, that allow adaptive social functioning (Kennedy & Adolphs, 2012) by recognising, manipulating, and responding to complex social stimuli in a flexible way (Adolphs, 2001, 2009; Beaudoin & Beauchamp, 2020).

Differentiating the concepts of social brain, social behaviour, and social cognition is important due to their interconnected yet distinct nature. The term "social brain" refers to the specific brain structures associated with social cognitive processes, distinguishing them from non-social processes and facilitating social cognition. Social behaviour encompasses the observable interactions between individuals, inherently involving social cognitive processes. On the other hand, social cognition is closely tied to cognitive processes that specialise in the social domain. These cognitive processes operate at both conscious and unconscious levels, contributing to our understanding and enactment of social behaviour (Kennedy & Adolphs, 2012).

Adaptive social functioning depends on the speed and efficiency of myelinated bundles and fibres throughout the brain since the structures associated with the social brain are spread not only by the five cerebral lobes and both hemispheres but also by portions of the cerebellum (Wang & Olson, 2018). These regions are associated with multiple cognitive abilities such as perception, attention, language, memory, executive function, mind reading, and decision-making (Wang & Olson, 2018; Beaudoin & Beauchamp, 2020). The structural regions associated with social cognition that activate whenever the individual tries to understand other people are the dorsomedial prefrontal cortex (dmPFC), posterior superior temporal sulcus (pSTS), temporoparietal junction (TPJ), anterior temporal cortex (ATC), inferior frontal gyrus (IFG), anterior temporal cortex (ATC) (Kilford et al., 2016; Frith & Frith, 2006), orbitofrontal cortex (OFC), amygdala, and anterior insula (AI) (Frith & Frith, 2006).

According to the recent literature on social neuroscience, there are three distinct neural circuits related to social cognitive processes (Wang et al., 2018): the face perception network (Corbett et al., 2014; Duchaine & Yovel, 2015; Lopatina et al., 2018; Wang et al., 2018), the mirror network (Barrett & Satpute, 2013; Gallese, 2009; Hyder,

2020; Schulte-Rüther et al., 2007; Wang et al., 2018), and the mentalising network (Barrett & Satpute, 2013; Hyder, 2020; Schulte-Rüther et al., 2007; Wang et al., 2018). Some of these processes are related to social perception, mentalising or Theory of Mind (ToM), empathy, moral judgements, and social norms understanding (Baksh et al., 2018; Kilford et al., 2016).

It should be acknowledged that all these networks will be reviewed but not all will undergo detailed analysis in this study, as the present investigation focuses on specific aspects of social cognition and social behaviour, such as ToM and understanding of social norms. However, it is important to recognise the interconnected nature of these processes.

1.2. Face perception

Social perception is a process within social cognition that encompasses the ability to analyse various cues, including facial expressions, gaze direction, body language and vocal changes (Arioli et al., 2018; Voos et al., 2013). Moreover, it involves the capacity to evaluate intentions and anticipate behaviour (Arioli et al., 2018). Body movement shows when a person is prepared to act and respond to stimuli, and the voice reveals emotion through prosodic elements. Face perception and recognition are the most studied processes related to social cognition. These are the most developed social abilities in humans and have a significant impact on their interaction with conspecifics (Corbett et al., 2014; Wang et al., 2018). They allow adjusting of behaviour through social information such as "identity, emotional expression and direction of the gaze" (Kilford et al., 2016, p. 107) and also "levels of familiarity, attractiveness and emotional state" (Lopatina et al., 2018, p.1). According to Arioli et al. (2018), gaze direction, eye movement pattern, and facial expression have rich informational value and support the recognition of the intentions of others and are therefore very important to the mentalisation processes.

An alteration or loss of ability to recognise faces may be associated with difficulties in visual face perception and memory problems, causing complications in social interactions (e.g., autism spectrum disorders) (Lopatina et al., 2018).

There are several hypotheses and models that attempt to decode the neurocognitive mechanisms that support the perception of faces; the model by Haxby et al. (2000) is the most influential. This model suggests a core system that carries out the perception and analysis of visual features of the face. The occipital face area (OFA) has

been engaged in face processing since the early stages and relates to the fusiform face area (FFA) which is important for face identity and process invariant aspects of the face. The superior temporal sulcus (STS) also receives information from the OFA and is related to changeable and dynamic aspects of the face (e.g., expression and gaze). Connected with this core, there is an extended system that processes other information: the anterior temporal lobe (ATL) stores semantic representations (Duchaine & Yovel, 2015), has conceptual and biographical knowledge of faces (Wang et al., 2018), and is theorised to be important to the recognition of familiar faces; the amygdala and limbic system (Duchaine & Yovel, 2015) interpret and recognise emotional information on the face; the inferior frontal gyrus (IFG) is related to semantic aspects and gaze direction, and the orbitofrontal cortex (OFC) processes reward aspects such as attractiveness and trustworthiness (Wang et al., 2018).

1.3. Mirroring Network and Embodied Cognition

The faces, voice, and body also influence emotional experience through “sensory feedback which (…) modulates the intensity of feelings" (Arioli et al., 2018, p. 3). During peer interaction, synchronisation can be observed in nonverbal communication, for example, in facial expressions, body posture, and gestures (Lieberman, 2007; Wang et al., 2013). Mirror imitation is an unconscious and automatic (Likowski et al., 2012) mechanism of social cognition that is externally focused and activated when the person performs and observes a goal-oriented action (Lieberman, 2007).

The Mirror Neuron System (MNS) enables an individual to understand the goals of another person's motor action and imitate it, which is important for the learning process and social behaviour (Hyder, 2020; Lieberman, 2007; Wang et al., 2018). Similarly, when observing a particular emotion in an individual's facial expression, there is mimicry at the neuronal level (e.g., disgust activates the anterior insula) that allows simulation, decoding, and recognition of the social meaning of expressions and emotions (Bonini et al., 2022; Carr et al., 2003; Hyder, 2020; Schulte-Rüther et al., 2007), which is called the embodied simulation mechanism (Gallese, 2009). Thus, it is theorised that this emotional resonance or contagion between individuals is essential for the development of empathy (Baron-Cohen et al., 2013; Carr et al., 2003; Decety & Meyer, 2008; Hyder, 2020) and perspective-taking (Woodruff, 2018). This mechanism also makes an important contribution to the perception of human speech and language (Bonini et al., 2022).

The MNS functions through the interaction between the core mirror neuron system and the limbic system (Rajmohan & Mohandas, 2007) and depends on the action or internal state that is perceived by the individual (Baron-Cohen et al., 2013). It integrates the IFG and the STS which are recruited in understanding the kinematic characteristics of an action, the inferior parietal lobe (IPL) which encodes the action outcome, and the anterior intraparietal sulcus (aIPS) which is sensitive to the intention of an action (Hyder, 2020; Van Overwalle & Baetens, 2009; Wang et al., 2018). The perception and experience of emotions activate the anterior cingulate cortex (ACC; associated with empathy for pain), anterior insula (AI; associated with empathy for disgust), and amygdala (associated with empathy out of fear) (Bonini et al., 2022; Hyder, 2020; Wang et al., 2018).

1.4. Mentalising and Theory of Mind

The mentalising network enables an individual to attribute or infer about the other's mental state, such as their intentions, desires, thoughts, and emotions, to predict behaviour (Frith, 2007) and be successful in social interaction. This ability is a process within social cognition, and it is often referred to as theory of mind or cognitive perspective-taking (Wang et al., 2018) and implies that the individual is aware that other people have mental states different from their own (Frith & Frith, 2006). In the present study, we refer to mentalisation and ToM interchangeably.

Authors hypothesise that MNS is the basis for understanding the intention of action only through MNS activation, however, this idea is still not consensual among authors (Geiger et al., 2019; Zarka et al., 2021). Hickok (2009) indicated that it is possible to understand an action without ever having performed it; therefore, it is possible to understand the action without the necessary involvement of mirror neurones (Hickok, 2009; Zarka et al., 2021). Thus, it is theorised that through the mirroring network, the individual is able to perceive, predict, and coordinate the action of the other (Bonini et al., 2022). However, mentalisation processes are also necessary to understand the communicative intention of actions, namely, to infer more abstract concepts (Hyder, 2020; Mainieri et al., 2013), in the absence of biological movement (Van Overwalle & Baetens, 2009), or when mirroring systems fail to observe movement (e.g. when the information is read) (Van Overwalle & Baetens, 2009). Frith and Frith (2006) explain that MNS is not enough to infer about others and that it is also necessary to have the

ability to take the perspective of the other and use knowledge about the world and the context to be able to anticipate or predict the future or action. This means that there might be interactions and information sharing between the networks. This network benefits from the processing of faces as it provides important information about their internal states through facial expressions (Frith & Frith, 2006). Thus, the MNS "provides rapid and intuitive input to the mentalising system" (Van Overwalle & Baetens, 2009, p. 567), and the mentalising system influences the low-level perceptual processes with long-term knowledge (Arioli et al., 2018).

ToM can be categorised into cognitive ("cold") and affective ("hot") ToM where "affective tasks often involve implicit process whereas more cognitive tasks rely on explicit processing" (Molenberghs et al., 2016; p. 289). While cognitive ToM focuses on the inference of beliefs, thoughts, or intentions, affective ToM is associated with understanding emotions and/or feelings (Molenberghs et al., 2016). Affective ToM is predominantly linked to simulation processes, face and body perception, and with a broader network than cognitive ToM. The authors also propose that affective ToM can be more sensitive to lesions because it relies on a "more distributed neural network" (Molenberghs et al., 2016, p. 289).

To understand one's mental state and that of others, a connection with executive functions is necessary, as they support the monitoring and control of thoughts and actions. Therefore, self-regulation, cognitive flexibility, inhibition, resistance to interference, and planning are important for mentalising, metacognitive abilities, and perspective-taking (Decety & Meyer, 2008).

The medial prefrontal cortex (mPFC), precuneus, and temporoparietal junction (TPJ) are considered a core network for mentalising because they are commonly activated in different experimental tasks (Baron-Cohen et al., 2013; Molenberghs et al., 2016; Van Overwalle & Baetens, 2009). There is also evidence of activation of other areas, such as the amygdala, STS, posterior and anterior cingulate cortex, IFG, and temporal lobes (TL), which are responsible for activation in specific types of ToM (Molenberghs et al., 2016). It is interesting to notice that these regions overlap with the default mode network (DMN), which is associated not only with "self-referential thinking, daydreaming, reminiscing and future planning", but also with "thinking about other people's beliefs, intentions and motivations" and supports the capacity for abstraction, important for inferring abstract concepts (Arioli et al., 2021, p. 4791).

Studies have shown that the mPFC is activated when tasks involve thinking about oneself and others (Centelles et al., 2011); the TPJ is important for perspective-taking (Centelles et al., 2011) and is related to inferences about people's goals, desires, and beliefs (Van Overwalle & Baetens, 2009), while the precuneus, on the other hand, can be important for identifying or retrieving contextual, situational, and autobiographical information so that the person can infer about the internal state of another person based on their previous experience (Molenberghs et al., 2016; Van Overwalle & Baetens, 2009). The specificity of each region is still unclear (Wang et al., 2018; Atique et al., 2011), and there is debate in the scientific community regarding the neuronal network due to (lack of) distinction in the classifications between affective and cognitive ToM (Arioli et al., 2021; Molenberghs et al., 2016).

It is also important to note that the amygdala is a central region in the social brain and is associated with the processing of social expression and judgment of trust, with abnormal consequences if injured (Arioli et al., 2018), such as the inability to become aware of danger (as in the case of SM who had bilateral amygdala damage due to Urbach-Wiethe disease; Tranel & Hyman, 1990).

1.5. Social Norms and Behaviour

As noted in previous chapters, social cognition is comprised of processes that work dynamically to allow the individual to have a set of behaviours and expectations related to others and their environment, which helps them succeed in their social interactions (Baksh et al., 2018; Kilford et al., 2016; Lee et al., 2022). One of these processes is the awareness or understanding of social norms, which helps individuals maintain adaptive social functioning and is important in guiding social behaviour in groups and communities (Lee et al., 2022).

Social norms are informal codes of behaviour constructed by society to regulate actions considered acceptable and appropriate, ensuring order and cohesion within a community (Bicchieri et al., 2006; Burke & Young, 2011). These norms serve as guidelines for social interactions and behaviour, and deviations from them can lead to negative repercussions (UNICEF, 2021). Therefore, social norms play a vital role in facilitating social functioning by providing a framework for expected behaviours and maintaining social order (Burke & Young, 2011).

Mentalising is important for understanding and internalising social norms. Through this process, individuals can deduce and anticipate the thoughts, emotions, and intentions of others, enabling them to predict their behaviour and appropriately apply social rules accordingly (Civai & Sanfey, 2021). The inference of social norms activates specific brain regions associated with mentalising, such as the precuneus, temporo-parietal junction, and medial prefrontal cortex (Pegado et al., 2018), highlighting the significance of these mechanisms in understanding social behaviour. These findings have important implications for understanding the potential decline or impairment of these mechanisms (Civai & Sanfey, 2021).

In general, healthy, and neurotypical individuals do not have difficulty understanding imposed social norms. On the other hand, individuals with neuropsychological disorders and dementia tend to have greater difficulty perceiving them (Panchal et al., 2015). One characteristic of someone with impaired social cognition is ignoring everyday social norms and abnormal social behaviour, which is consequently considered inappropriate (Desmarais et al., 2017). For instance, in the frontotemporal dementia-behavioural variant, behavioural disinhibition and lack of decorum are core symptoms of the diagnosis which can be perceived by others as inappropriate or rude behaviours, therefore deviating from social norms (Braak et al., 2022; Panchal et al., 2015)

In 2018, Ganguli and colleagues conducted a study to provide normative descriptive data on the Social Norms Questionnaire (SNQ-22). This questionnaire assesses a person's understanding and awareness of social norms and the study found that older adults with “higher literacy and premorbid intellectual ability, lower dementia rating, and higher scores in all the cognitive domains” tended to have better scores on the questionnaire. On the other hand, inferior performance on the questionnaire was associated with “greater age and male gender” (p.6). The authors suggest that age-related results may be more related to cohort effects rather than the ageing process itself. However, the results highlight the importance of considering cognitive ability and age when measuring awareness of social norms. Additionally, the study notes that perceptions of normative behaviour can also vary depending on culture (Ganguli et al., 2018).

Although the research about social norms and individuals' decision-making in social contexts is crucial, it remains relatively understudied, especially in the context of

healthy ageing. Further research is needed to gain a better understanding of this topic within the field of social cognition.

1.6. Social Cognition and Ageing

Social cognition develops throughout the life cycle and increases in complexity. Mimicry processes begin to develop from birth (Keysers et al., 2013); first-order belief reasoning implies understanding another person's mental state and is acquired at four years of age; emotional contagion is also developed prematurely, compared with perspective-taking. Mentalisation processes mature until advanced adulthood due to social demands (Roheger et al., 2022a; Yıldırım et al., 2020). These processes have been studied in older adults through differential activation of brain regions between young and elderly adults (e.g., Ruitenberg et al., 2020) and by assessing co-activation between brain regions that connect during the resting state (e.g., Hughes et al., 2019).

In addition to social cognition, general cognitive functions are important for adapting behaviours to social contexts and interactions (Beaudoin & Beaucham, 2020). However, there is evidence of structural and functional changes related to ageing (Hughes et al., 2019), and researchers hypothesise the possibility of a decline in social cognition, like a decline in general cognitive functions (Yıldırım et al., 2020).

In normative ageing, cognitive decline is usually translated into a decrease in processing speed, memory capacity, executive function, and complex reasoning capacity. These functions play an important role in social cognition and are activated in the presence of relevant social stimuli. It is also possible to find preserved or potentially improved areas due to the experience gained with age, such as language and general knowledge (Arioli et al., 2018; Kalokerinos et al., 2017; Maresca et al., 2020). This means that age-related changes are related to both losses and gains.

When assessing cognitive loss in normal ageing, it is important to understand the interactions between numerous processes and mechanisms that can mediate, prevent, and compensate for such losses (Arioli et al., 2018; Kalokerinos et al., 2017). Some of these processes include cognitive reserve, education, level of fluid cognition, and the availability of resources (Arioli et al., 2018). Mental activity can delay and compensate for cognitive decline. For example, older adults who have attained higher education and a complex and cognitively challenging occupation and daily life may have a higher level of cognitive reserve and resources (Kalokerinos et al., 2017; Tucker & Stern, 2011).

Age-related changes in social cognition can be more complex because of the interaction of "motivational and emotional changes brought about by changes in life goals (...) with changes in cognitive function to produce diverse patterns of responding" (Kalokerinos et al., 2017, p. 2168). Consequently, it is necessary to understand general cognitive decline, the variables that influence it, and the emotional changes that occur with age. Thus, the question arises as to whether social cognition changes rely only on general cognition or whether experience can help compensate for these deficits (Kalokerinos et al., 2017). Accordingly, Arioli et al. (2018) reiterate that the decrease in social cognition is intertwined with age-related loss of general cognition and shifts in motivation and life goals.

To analyse and measure age-related changes in social cognition, it is important to understand the cooperation and competition between automatic and controlled processes that modulate behavioural responses (Arioli et al., 2018; Kalokerinos et al., 2017). These dual processes function in a compensatory manner. The automatic process is inhibited by cognitive control processes, which are the most harmed by ageing; therefore, there is an apparent increase in automatic processes when this occurs. This weakening of the controlled processes may be linked to behavioural changes, such as disinhibition and poorer decision-making. In contrast, the automatic processes allow older adults to use "automatic heuristics, which are fast, effortless, and generally accurate enough for most everyday purposes" (Kalokerinos et al., 2017, p. 2172).

1.7. Social cognition in Ageing: interplay with emotion recognition and regulation

This entry will outline how experience, motivational changes, and automatic and controlled processes can change the components of social cognition and social functioning in older age groups.

Faces give social signals that are important for effective communication and social functioning, however, with ageing there is a change in the social perception of faces (Arioli et al., 2018).

In their study, Ziaei et al. (2016) showed evidence that older adults have more difficulty recognising angry faces than happy ones compared to young adults. According to this study, younger adults use two neural networks to recognise angry faces. They activate the salience network when the gaze is directed towards themselves; however,

when the gaze is averted, they use frontoparietal regions, recruiting cognitive and executive operations. However, the elderly use only distributed regions. The authors associate this finding with the Theory of Dedifferentiation, which implies that the elderly need more resources to process angry faces than young adults do.

Older adults also use two neural networks to recognise expressions of happiness, unlike young adults, which may be associated with Socioemotional Selective Theory (SST; Arioli et al., 2018). SST consists of an assumption were individuals with older age change the direction of the focus of attention and motivation towards meaningful goals and positive information, making recognition easier (Carstensen et al., 2003; Arioli et al., 2018). There is also a change in strategy in processing faces, where older adults focus more on the mouth or nose, which are more related to happiness and disgust than eyes. This suggests a functional and/or structural change in the STS, medial PFC, and amygdala, which are associated with decoding and gaze perception (Arioli et al., 2018). These findings imply that one change that occurs in older adulthood is that they tend to prioritise emotional and social goals, processing more positive information over negative information, exhibiting a neural pattern that indicates "controlled downregulation of negative emotion" (Kalokerinos et al., 2017, p.2169).

In contrast to this decline in emotion recognition, this shift in motivation may contribute to the preservation of emotional regulation by individuals "allocating more resources on emotional processing and emotion regulation strategies" (Arioli et al., 2018, p.9). There is evidence that older adults are better than younger adults at regulating emotions, exhibiting fewer cognitive emotion regulation strategies (e.g. cognitive reappraisal) that are learned and accumulated throughout their life experiences (Kalokerinos et al., 2017).

1.8. Social Cognition in Ageing: cognitive and affective Theory of Mind

The benefits of being capable of mentalising are significant, as it allows us to understand that others may have different intentions, beliefs, or knowledge than ours. Moreover, it enables us to acknowledge that their interpretation of reality, based on the information we provide, may not align with actual reality or our interpretation of it (Sidera et al., 2016). Mentalising not only helps predict others' behaviours, but also enables the possibility of manipulating the behaviour or beliefs of others by disseminating false or true information (Frith & Frith, 2005).

Even in a simple social interaction, there exists an "interplay between processing the self and processing others" (Maresh & Andrews-Hanna, 2021, p. 630) where it is essential to understand and take perspective about the other's mental state, intentions, and emotions. Therefore, the process of mentalisation comprises cognitive and affective processing that "could be mediated by interacting, but [have] dissociated neural networks" (Wang et al., 2013, p. 289). While cognitive ToM involves making inferences about others' thoughts and beliefs (belief about belief) and relies on controlled processing, affective ToM involves understanding others' emotions and feelings (belief about emotions and feelings) and is considered an automatic and embodied process (Bottiroli et al., 2016; Luyten et al., 2021).

The perception of older adults is that they are good mind readers and good at making judgments and inferences about others, not detecting deficits. This subjective feeling would mean that age would not affect cognitive or affective ToM (Duval et al., 2011). However, in recent years, several studies have explored the impact of healthy ageing on cognitive and affective ToM, yielding controversial results. Initial studies of social cognition in the elderly, such as that by Happé et al. (1998), align with the perception of older adults and showed that they performed better in mentalising tasks than younger ones as they benefited from their experience of how people behave and react to certain situations. Thus, older adults showed only a deficit or decrease in performance in cognitive tasks unrelated to ToM. However, confounding variables called into question the conclusions, such as the lack of control between general cognitive abilities (e.g., crystallised and fluid intelligence) and working memory (Moran, 2013). On the other hand, other studies indicate age-related changes in both cognitive and affective ToM, while others show relative preservation (Moran, 2013; Henry et al., 2013; Ruitenberg et al., 2020).

In recent years, the most controversial results in the literature have been related to affective ToM, where there is no agreement between the findings. Duval et al. (2011) observed that older adults performed poorly on cognitive and affective ToM tasks compared to young and middle-aged adults. In addition, since no significant differences were found between young and middle-aged adults, the authors suggested that the impairment of cognitive and affective ToM abilities occurs after 70 years of age (Duval et al., 2011). On the other hand, Li et al. (2013) found age-related effects on cognitive but not affective ToM in individuals over 70 years old.

Other researchers, such as Yıldırım et al. (2020) and Bottiroli et al. (2016), indicate the preservation of affective ToM with ageing. Yıldırım et al. (2020) suggested that affective ToM is mediated by automatic processes and general cognition rather than controlled processes or executive function. This suggests that the processing is faster and effortless and less susceptible to ageing compared to controlled processing, which could explain the preservation of affective ToM (Fonagy & Bateman., 2019; Henry et al., 2023; Kalokerinos et al., 2017). However, others, such as Duval et al. (2011), and Ruitenberg et al. (2020) postulated that a change is associated with both affective and cognitive ToM. Ruitenberg et al. (2020) point out that there is no deficit in affective ToM, as performance remains favourable, but older adults require more time on task to make the correct decision.

In contrast, the studies cognitive ToM have generated some consensual results, with an agreement regarding a decline associated with ageing (Duval et al., 2011; Bottiroli et al., 2016; Yıldırım et al., 2020; Ruitenberg et al., 2020). The authors consistently suggest that the decline of cognitive ToM in older adults is associated with the deterioration of executive functioning, especially inhibition and working memory, and other contributors include "vocabulary, reasoning, episodic memory, and processing speed' (Yıldırım et al., 2020, pp. 208-209). Thus, unlike affective ToM, cognitive ToM is mediated by executive function and is considered to require more controlled processing, which involves "reflection, attention, awareness, intention, and effort" (Fonagy & Bateman, 2019, p.8) and is more prone to decline with ageing (Kalokerinos et al., 2017).

The literature establishes that executive function and ToM development are linked. When inferring others' beliefs, one needs to inhibit representations of the self and knowledge to adopt the other's point of view (Chainay & Gaubert, 2020; Cho & Cohen, 2019). However, it is not possible to state whether the ToM decline in older age is caused by a decline in executive functions or a decline in ToM competence (Cho & Cohen, 2019). Executive functions are higher-order processes that include "task switching, working memory, inhibition of thought and behavior" (p.2169), and mostly recruit the frontal lobe, which is the area more prone to age-related deterioration (Kalokerinos et al., 2017). According to Arioli et al. (2018), executive processes are at least partially impaired in older adults, so there is a decrease in the ability to inhibit automatic behaviours, which can result in disinhibition, prejudice, and inappropriate behaviours. Although some

authors hypothesise that the decline in executive function with age may affect performance in ToM tasks (Henry et al., 2013), there are also contradictory results (Lucena et al., 2020), with some studies indicating this correlation (Henry et al., 2013; Yıldırım et al., 2020; Maresca et al., 2020) and others showing no association and indicating ToM-specific impairment (Youmans & Bourgeois, 2010).

These contradictions may be related to the authors' use of heterogeneous methodologies, such as tasks with different modalities (verbal, non-verbal and/or visual; dynamic images or static images, and narratives) and different levels of difficulty (for example, without comparing reasoning involving first-order and second-order beliefs) (Ruitenberg et al., 2020; Henry et al., 2013). It may also depend on the ToM category studied such as affective or cognitive ToM. (Arioli et al. 2018). Ruitenberg et al. (2020) also emphasise that the type of task and its difficulty can vary the involvement of cognitive and executive functions in the individual's performance.

1.9. Ageing, social cognition, and social isolation: relation with the risk of dementia

Social isolation and loneliness are two connected concepts, albeit meaning and being measured differently. Social isolation occurs when there is a lack of social support, communication, and interaction with other people, being an objective condition that can be measured by factors such as the size of one's social network, and marital status, among other factors. On the other hand, loneliness is a subjective perception stemming from unmet expectations and a sense of dissatisfaction with existing social interactions. This means that one can feel lonely without being socially isolated, but both constructs can have a negative impact on health (Morese & Palermo, 2022; Ren et al., 2023)

As individuals age, they may progressively experience social isolation, which can detrimentally impact general and social cognition (Morese & Palermo, 2022; Okruszek et al., 2021). Loneliness and social isolation at this stage of life can be exacerbated by the death of loved ones, chronic illnesses, sensory impairment (e.g. hearing loss), retirement or changes in income, and other disruptive events (Morese & Palermo, 2022; National Academies of Sciences, Engineering, and Medicine [NASEM] et al., 2022). Notably, the transition from employment to retirement often brings about significant changes in one's social network, making it a critical period that can have adverse effects on mental health (Holt-Lunstad et al., 2015). During this transition, individuals tend to experience a

reduction in their social network and interactions, leading to a decrease in friendships and an increased risk of experiencing feelings of loneliness and social isolation (NASEM, 2022). Thus, older adults that live alone and do not engage in social activities "are undoubtedly made more frailty by a possible deprivation of a social support network (family or friends) that they can rely on in times of need" (Morese & Palermo, 2022, p. 5).

Additionally, the size of social networks is associated with the level of socio-cognitive skills (Lewis et al., 2011). According to Han et al. (2021), to build a social network, it is necessary to preserve the mechanisms of social cognition such as mentalisation and mirroring networks. Thus, individuals with (qualitatively or quantitatively) complex social networks may have both a greater capacity for social cognition and social resources, as well as a more developed general cognitive capacity, (Pillemer et al., 2016; Stiller & Dunbar, 2007), whereas those with a limited social network tend to experience greater difficulties in navigating social interactions (De Lillo et al., 2022). These findings are congruent with some studies who concluded that stronger social networks and the perception of a high level of social support can prevent cognitive deterioration, owing to greater functional connectivity (Pillemer et al., 2016).

However, as outlined in the previous chapters, older adults may experience a decline in social cognition performance, facing greater difficulty in inferring mental states in complex social contexts and recognising basic emotions (Arioli et al., 2018). This difficulty can increase the risk of loneliness among the elderly (Haslam et al., 2017; Morese & Palermo, 2022). Research indicates that individuals lacking social contact and possessing smaller social networks, resulting in reduced social support, and increased social isolation, may have a lower life expectancy, "with social network predicting longevity" in individuals over the age of 70 (Haslam et al., 2017, p. 2175). Therefore, isolation can have harmful consequences, contributing to poor mental and physical health, heightened stress, increased mortality, and greater susceptibility to age-related pathologies, such as dementia (Arioli et al., 2018; Evans et al., 2019; Hughes et al., 2019). On the other hand, there is also strong evidence that social engagement and participation in social activities protect mental and cognitive health and reduces the risk of dementia and mortality (Haslam et al., 2017; Livingston et al., 2020; Mahalingam et al., 2023; Morose & Palermo et al., 2022).

In their study, Lisko et al. (2020) also identified reduced social participation, limited contacts and perceived social isolation as modifiable risk factors associated with the development of dementia, along with other factors such as obesity, hypertension, dyslipidaemia, diabetes, sedentary lifestyle, poor dietary habits, lack of mental and social stimulation activity, poor diet, lack of mental and/or social stimulation, depression, stress. These modifiable risk factors differ from non-modifiable risk factors, such as age, sex (being female), and genetic traits, as they involve various lifestyle and environmental factors that can be altered or controlled. Research estimates that up to 40% of dementia cases can be prevented through behavioural changes and public health measures targeting modifiable risk factors (Horstkötter et al., 2021; Livingston et al., 2020).

In this study, social isolation, loneliness, and limited social networks emerge as critical psychosocial risk factors due to their significant impact on social and cognitive decline and the heightened incidence of dementia (Lisko et al., 2020). A 4-year longitudinal study showed an association between loneliness and a higher risk of being diagnosed with Alzheimer's disease or a more significant cognitive decline in all functional domains. However, the authors did not definitively conclude whether loneliness resulted from dementia onset or whether loneliness itself contributed to the deterioration of the neuronal system (Wilson et al., 2007). Researchers hypothesise that there is a bidirectional association between social isolation and cognitive decline, as general cognitive deficits and cognitive social problems can lead to progressive isolation. In turn, isolation and withdrawal from social activities can support the deterioration of cognition and worsen difficulties in daily living (Cacioppo & Hawkley, 2009; Cardona & Andrés, 2023; Eramudugolla et al., 2022; NASEM, 2020; Porcelli et al., 2018).

Although ageing does not necessarily imply the experience of loneliness, and both social isolation and loneliness are risk factors for cognitive decline, it is advised to recruit strategies to compensate for deficits in social cognition and encourage greater social involvement to prevent signs of Mild Cognitive Impairment (MCI) and dementia (Eramudugolla et al., 2022). Meng et al. (2022) also suggest multidomain interventions, that is, interventions that combine multiple domains, such as physical, cognitive, and social factors, are more effective in preventing dementia and improving cognitive functions.

1.10. Social cognition and ageing: importance of social cognition in dementia prevention

Understanding how people think about and interact with each other (social cognition) is a strong predictor of how well they navigate social situations "(…) sometimes even stronger than non-social cognitive processes in psychiatric populations" (Henry et al., 2021, p.2). Moreover, some studies have highlighted the significance of social cognition as an important clinical marker that indicates neurological abnormalities across various clinical conditions, emphasising the need for further attention and investigation (Cotter et al., 2018). Acknowledging its importance, the 5th edition of the American Psychiatric Association's (APA) Diagnostic and Statistical Manual for Mental Disorders (DSM-5) has included social cognition as a core domain of neurocognitive function and recognises that it can be affected by neurodegeneration (APA, 2013; Lee et al., 2022).

The interplay between an individual's interactions with their social environment has a dynamic nature, which can influence social cognition and the social brain either positively or negatively over time, particularly as individuals age (Cacioppo & Hawkley, 2009; Morese & Palermo, 2022). Within this context, cognitively unimpaired adults may face an increased risk of developing dementia due to psychosocial factors such as social isolation and reduced social engagement. Furthermore, these factors often have adverse effects on social cognition (Jacob et al., 2019), and are reciprocally influenced by it (Arioli et al., 2018), suggesting possible a bidirectional association (Cacioppo & Hawkley, 2009; Cardona & Andrés, 2023; Eramudugolla et al., 2022; NASEM, 2020; Porcelli et al., 2018).

Research suggests that individuals with MCI, that may be seen as a pre-clinical phase of dementia, experience more pronounced impairments in social cognition compared to healthy elderly. These impairments can lead to reduced social participation, loneliness, and age-related conditions (Moreau et al. 2014; Roheger et al., 2022b). To build a neuropsychological profile in individuals without dementia but with increased risk for developing dementia that incorporates social cognition measures could possibly contribute to understand the pathways of social cognition impairment and thus contribute to implement techniques to stimulate social cognition in these individuals.

A strong social cognitive profile has been associated with a “higher quality of life, emotional well-being, and social functioning throughout life” (Roheger et al., 2022b, p. 8). Therefore, studying of social cognition in the context of dementia prevention is essential, as it could not only enhance our understanding of normative and pathological ageing processes but also allows for the development of protocols focused on assessing and intervening of social cognition in the continuum process between normative and pathological ageing (Kalokerinos et al., 2017; Roheger et al., 2022b). Understanding the pattern of decline in social cognition components could eventually help to develop training interventions for these same components, psychoeducation, and socio-cognitive skills training (Lucena, 2020), in the case they prove to be impactful in the psychosocial risk factors for dementia. Accordingly, the development of social cognition interventions could eventually delay cognitive deterioration by reducing the negative impact of social isolation on mental and cognitive health and increase the person's potential to expand their interpersonal network (Christidi et al., 2018).

While dementia prevention programs have focused on various factors such as exercise, nutrition, and social engagement in cognitively healthy adults at risk of dementia (Lehtisalo et al., 2022; Ngandu et al., 2015), social cognition has been a largely overlooked domain. Neglecting this aspect may result in missing valuable insights and potential interventions that could assist individuals at risk of developing dementia. As such it is important to investigate the relationship between social cognition and dementia risk in cognitively healthy older adults. By acquiring a comprehensive understanding of the social cognition profile of individuals at high risk, we can identify potential intervention targets and design customised programs that specifically address these cognitive processes. This approach not only yields valuable data for the implementation of effective prevention strategies but also plays a crucial role in enhancing the overall well-being and quality of life for older adults at risk of dementia.

II. Methodology

2.1. Goals and Hypotheses

The present study aims to investigate the potential relationship between social cognition profile and the risk of dementia. In other words, we aim to investigate if individuals at higher risk of dementia will demonstrate lower levels of social cognition compared to individuals with lower risk, concerning the modifiable risk factors. Through this endeavour, our objective is to gather valuable insights in a relatively unexplored domain. To the best of our knowledge, this study represents the first attempt to investigate the association between these two concepts. Furthermore, our intention is to collect data that can contribute to the development of effective dementia prevention programs may that integrate social cognition as a relevant component.

Considering the literature review and in line with the defined research objectives, the following hypotheses have been formulated based on the literature:

H1: Age differences exist in the performance of social cognition instruments, with older participants exhibiting poorer performance than younger participants in both Theory of Mind and Social Norms measures.

H2: Participants with higher risk of dementia will have poorer performance in social cognition instruments.

H3: There is a positive association between performance in cognitive tests and performance in social cognition tasks.

H4: There is a significant association between the size of social networks, levels of social isolation, and/or education levels with the risk of developing dementia and social cognition performance.

H5: The social cognition performance significantly predicts risk of dementia.

2.2. Participants

Following the literature review, hypotheses were developed based on existing theoretical frameworks. To assess these hypotheses, a non-probabilistic sample was collected using convenience sampling spanning from January to May 2023. A total of

122 participants were recruited from the community in mainland Portugal, with a focus on both central coastal and inland regions. The age range of the participants was from 55- to 75-year-old. The participants underwent a comprehensive neuropsychological assessment protocol.

Inclusion and exclusion criteria were established to select the participants, as can be observed in Table 1. As a result of these requirements and missing values, it became necessary to exclude 11 individuals, leaving our sample with a total of 111 participants.

Table 1

Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Participants must fall within the age range of 55 to 75 years.	Participants who are younger than 55 years old or older than 75 years old.
Participants should not exhibit cognitive and/or sensory deficits.	Participants with cognitive and/or sensory deficits.

2.3. Protocol Assessment and Procedures

The protocol used in the present study is part of a larger dementia prevention study "REMINDER", submitted and approved by the Faculty of Psychology and Education Sciences of The University of Coimbra Deontology and Ethics Committee for Research (CEDI/FPCEUC:62/8). After agreeing with the participation in the study and filling the informed consent form, participants underwent a social demographic interview and individual testing on a 2-hour battery that evaluated both cognitive performance, social cognition, emotional and functional status. The battery was individually administered by neuropsychology trainees and research assistants after obtaining written informed consent. In the statistical analysis, variables from some of the instruments in the administered battery were excluded to prevent a loss of statistical power.

Social demographic interview

The semi-structured sociodemographic interview was conducted as the first stage of the evaluation process, with the aim of identifying potential inclusion or exclusion criteria for the study volunteers. The sociodemographic questionnaire allowed for the

extraction of information related to the volunteer's date of birth, age, area of residence, educational level, profession, and current and previous clinical information.

Healthy Lifestyle Assessment Toolkit for the General Public

The Healthy Lifestyle Assessment Toolkit for the General Public (Toolkit; Reis et al., 2019) was used to collect information related to sociodemographic data, healthy lifestyle practices, individual health conditions or diseases, self-perceived social support, self-perceived physical activity, well-being and sleep, social cohesion, and functional independence. Reliability assessments have not been conducted so far for this toolkit.

Cognitive reserve

To evaluate cognitive reserve, we utilised The Irregular Word Reading Test (TeLPI; Alves et al., 2018, 2012a, 2012b). The TeLPI is a brief administration test that aims to specifically evaluate premorbid intelligence and consists of 46 irregular words that participants must read aloud, thus assessing crystallised intelligence. TeLPI has revealed a very good internal consistency (Cronbach's alpha= 0,939) (Alves et al., 2012b).

Cognitive Performance

Global Cognition: The Addenbrooke's Cognitive Examination-Revised (ACE-R; Mioshi et al., 2006; Portuguese version by Firmino et al., 2018, 2008) was used to perform a cognitive screening evaluation on all participants. The test consists of 5 subdomains: Orientation and Attention, Memory, Fluency, Language, and Visuoconstructional Skills. It is an easy-to-administer test, with a duration that varies between 10 to 15 minutes and a maximum score of 100 points. Through this test, it is possible to obtain a score of the Mini-Mental State Examination that can range from 0 to 30 (MMSE; Folstein et al., 1975; Portuguese version by Guerreiro et al., 1994). Higher scores on both tests indicate better cognitive functioning. Reliability assessments have not been conducted in the Portuguese version; nevertheless, it's worth noting that the internal consistency of the original ACE-R by Mioshi et al. (2006) is regarded as very good with a Cronbach's alpha coefficient of 0.8, indicating strong reliability.

Memory: The Word List Test I and II of the Wechsler Memory Scale – 3rd Edition (WMS-III; Wechsler, 2008a) were used to evaluate verbal episodic memory. In Test I, four trials are conducted where the examiner orally presents List A, consisting of 12 words, followed by the participant's free recall. Afterwards, a second list of 12 words (List B) is read aloud, and participants are asked to recall the words freely. Then, a short-term free recall is conducted where the participant is asked to recall the words from the first list. Test II is conducted after an interval of 25 to 35 minutes, where the participant is requested to perform a deferred free recall trial related to the words from List A. Subsequently, a recognition task is conducted also referring to List A. The score is determined based on the number of correctly recalled words. The raw score ranges between 0 and 12 for all tasks except for the total immediate recall, which can range between 0 and 48, and the recognition task, which can range between 0 and 24 points. The raw score can be converted into a standardized score that ranges between 0 and 19 (M=10, SD=3). The internal consistency of the subtests varies between 0.70 and 0.90, ranging from questionable to good (Wechsler, 2008a).

Processing Speed: To assess processing speed, the Symbol-Digit Coding (SDC) subtest of the third edition of the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997, 2008b) was used. The test consists of a line where numbers 1 to 9 are associated with a set of symbols and the participant must reproduce this association in response to lines of randomly ordered numbers below. Thus, this test requires the participant to visually identify the indicated response and draw the correct symbol on each number. The subtest has a raw score range of 0-133, which can be converted to a standardized score range of 0-19 (*M*=10, SD=3). The reliability coefficient for this subtest is 0.88, indicating good internal consistency (Wechsler, 2008b).

Executive function: The Trail Making Test (TMT; Reitan & Wolfson, 1985; Cavaco et al., 2013a) was used to assess sustained and divided attention, cognitive flexibility, and processing speed of the participants. TMT-A is a subtest in which the individual must connect the numbered circles from 1 to 25 in ascending order and is more related to sustained attention and processing speed. On the other hand, TMT-B is a subtest that involves connecting numbered circles from 1 to 13 and letters from A to M in alternating ascending order, respecting alphabetical order and is related to the evaluation of divided attention, cognitive flexibility, and processing speed. For the evaluation, the

examiner times the time used to complete each test and tallies the number of errors committed (Cavaco et al., 2013a).

The Semantic and Phonemic Verbal Fluency Test (SVF and PVF) allowed the evaluation of semantic memory, verbal initiative, and executive functions (Strauss et al., 2006; Portuguese norms by Cavaco et al., 2013b). The norms by Cavaco et al. (2013b), which discriminate between sex, age, and education, were used to assess the results. Each correctly considered word is scored with 1 point, indicating that a higher score reflects greater language processing and production ability. This test demonstrates good internal consistency (Cronbach's alpha = 0.89) (Cavaco et al., 2013b).

The adult version of the "Behavior Rating Inventory of Executive Function" (BRIEF-A; Roth et al., 2005) is an inventory for assessing executive functions that is being validated for the Portuguese adult population (18 to 90 years old) at the time of this master's thesis. The inventory consists of 75 items with 9 clinical scales: Inhibition, Flexibility, Emotional Control, Self-Monitoring, Initiation, Working Memory, Planning/Organisation, Task Monitoring, and Materials Organisation. The BRIEF-A allows the participant to assess their own executive functions through the self-report form, and allows a significant informant, with good knowledge of the individual, to evaluate them through the hetero-report form.

Social Cognition

The Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001; Portuguese version by Pestana et al., 2018) and The Social Norms Questionnaire (SNQ-22; Kramer et al., 2014) were used to assess components of social cognition.

The RMET is commonly used to assess affective ToM, as it consists of 36 items where participants must recognise mental states from black and white photographs of the eye region. The participant has four options of mental states and must choose only one that corresponds to the target expression. The total score is 36 and higher scores indicate a better capacity for affective ToM (Pestana et al., 2018). There haven't been any reliability studies conducted on the Portuguese version of RMET.

The SNQ-22 was used to assess understanding and awareness of social norms, as well as social behaviour guided by norms. This questionnaire consists of 22 items in which the subject must respond "yes" or "no" regarding actions and behaviours that may or may not be appropriate and that occur in front of individuals whom the person is not

familiar with. The questionnaire has two subscales that are related to the two possible types of errors, such as "over-adherence" and "break norms". The score vary from 0 to 22 with higher scores indicate improved performance and a greater awareness of social norms (Ganguli et al., 2018). However, the Portuguese validation is ongoing.

Risk of dementia

To assess participants' risk of dementia, the "Lifestyle for Brain Health" index (LIBRA; Deckers et al., 2014; Schiepers et al., 2018) was used in its reduced version. This scale consists of 12 items that reflect modifiable risk factors and protective factors for the development of cognitive decline and dementia and is useful for "selecting and monitoring individuals in lifestyle-based prevention trials, taking into account different levels of initial risk" (Deckers et al., 2020, p.1206). Positive and higher scores correspond to higher dementia risk, ranging from -5.9 to +12.7 (Deckers et al., 2020). In the present dissertation, and according to relevant literature, scores higher than 0 were considered as “high risk” and scores lower than 0 were considered “low risk”.

Emotional functioning

To assess depressive symptoms, the 15-item Geriatric Depression Scale (GDS-15; Sheikh & Yesavage, 1986; Portuguese adaptation by Apóstolo et al., 2014) was used. The participant should consider their actions and feelings in the last week and respond on a dichotomous response scale (yes/no). The results range between 0 and 15, with the potential to indicate absence of depressive symptoms (0-4), presence of mild symptoms (5-8), moderate symptoms (9-11), and severe symptoms (12-15). The instrument demonstrates good reliability (Cronbach's alpha = 0.83) (Apóstolo et al., 2014).

Social network

The Lubben Social Network Scale-6 (LSNS-6; Lubben et al., 2006; Portuguese population adaptation by Ribeiro et al., 2012) was used to screen the risk of social isolation among participants, allowing the evaluation of the perceived and received support level from family and friends. Participants should answer the questions asked by quantifying the number of individuals and considering the definitions provided for “family” and “friends”. The scoring can range from 0 to 30 points, with a lower score

indicating greater social isolation. The internal consistency was deemed acceptable, with a Cronbach's alpha coefficient of 0.798 (Ribeiro et al., 2012).

2.4. Statistical Methods

To examine the specified hypotheses, the current study employs a quantitative cross-sectional research methodology. The statistical treatment of the data was carried out using the Statistical Package for the Social Sciences (SPSS) version 27 for Windows.

Preliminary analyses were performed to examine statistical assumptions, identify outliers, and missing data.

Descriptive statistics were applied to characterise the sociodemographic profile of the sample, encompassing frequencies expressed in percentages, means, standard deviations, and range.

To assess the presence of differences between age groups in social cognition (H1), and the differences between performance risk of dementia groups in social cognition measures (H2), independent samples t-tests were used. Significant differences will be considered when a value of $p<.05$ is obtained, according to Fisher (1973). The effect size was calculated by Cohen's d, suggesting that values between 0 and 0.2 are considered small, 0.2 to 0.5, 0.5 and 0.8 are considered large and superior to 1 is considered very large (Cohen, 1992).

To investigate a possible association between cognitive and social cognition performance (H3), as well as between dementia risk factors and the likelihood of developing dementia along with cognitive performance (H4), Pearson's correlations were employed. In accordance with Cohen's criteria (Cohen, 1988, 1992), values between 0.1 and 0.3 were interpreted as indicative of low correlation, values between 0.3 and 0.5 indicated moderate correlation, and values between 0.5 to 1 were considered strong correlations. The values can take on a positive value, indicating that the variables vary in the same direction, or negative values, indicating that they vary in opposite directions.

Finally, multiple linear regression analyses were conducted to explore whether social cognition performance predicts the risk of dementia (H5).

III. Results

3.1. Sociodemographic characterisation

As shown in Table 2, the final sample included in the study consists of 111 community-dwelling individuals, with a predominant proportion of females (64.9%). The participants' ages ranged from 55 to 75 years, with a mean age of 64.60 years (SD=6.547). A substantial portion of the participants are married (66.7%), and their educational levels spans a range of 3 to 23 years (M=11.35; SD=4.948), with the majority having completed university (34.2%) or high school (26,1%). In terms of employment status, most individuals are retired (55.9%), retiring at an average age of 60.75 (SD=4.115) years.

Table 2

Sociodemographic characteristics of the final sample (N=111)

Characteristics	N (%)	*M* (SD)	Min-Max
Gender			
Female	72 (64.9%)		
Male	39 (35.1%)		
Age		64.60 (6.55)	55-75
Education			
Primary Education	27 (24.3%)		
Middle School	16 (14.4%)		
High School	29 (26.1%)		
University	38 (34.2%)		
Doctoral degree	1 (0.9%)		
Marital status			
Married	74 (66.7%)		
Divorced	14 (12.6%)		
Widowed	16 (14.4%)		
Single	7 (6.3%)		
Retired			
Yes	62 (55.9%)	60.75 (4.12)	52-67
No	49 (44.1%)		

Note. Min = Minimum; Max = Maximum

With the purpose to understand and compare the profile of the individuals with higher risk of dementia and lower risk of dementia, the sample was dichotomised into two groups based on LIBRA results: a high dementia risk group (scores above 0 in LIBRA) and a low dementia risk group (scores below 0 in LIBRA), with 51.4% of the participants classified in the low-risk group and 48.6% in the high-risk group. With this clustering, as expected, the difference in LIBRA scores between the groups is statistically significant, as indicated by the independent samples t-test, $t(109)= -12.62$, $p<.001$, with a large effect size ($d=-2.4$) (cf. Table 3).

The low-risk group is predominantly composed of women (71.9%), and the same trend is observed in the high-risk group (57.4%). No significant gender differences were found between groups (X^2 (1, $N=111$) = 2.57, p=0.109). Additionally, there were no differences in age distribution between the low-risk group ($M=64.77$, SD=6.29) and the high-risk group ($M=64.43$, SD=6.86), as indicated by the independent samples t-test, $t(109)=0.28$, $p=.782$.

No significant differences related to the number of years in school between the two groups were observed, as indicated by the t-test result ($t(109) = 0.92$, $p=0.360$). The low-risk group has a mean of 11.77 years of education (SD=4.94), while the high-risk group has a mean of 10.91 years of education (SD=4.96).

The two risk groups are mostly composed of married individuals (Low risk - 64.9%; High risk - 68.5%), with no statistically significant differences found between groups, X^2 (3, $N=111$) = 0.60, $p=0.897$.

No statistically significant differences were observed between the groups in terms of retirement status, as indicated by the chi-square test result, X^2 (1, $N=111$)=0.004, $p=.951$, with the majority of individuals having retired in both the low-risk (56.1%) and high-risk (55.6%) groups. Similarly, there were no statistically significant differences in retirement age, $t(58)=.062$, $p=.951$. The mean age of retirement in the low-risk group is 60.78 (SD=4.20) and 60.71 (SD=4.099) in the high-risk group.

Statistically significant differences in depressive symptomatology (GDS) were observed between the two groups [t(109)=-2.55, p=.012], with the high-risk group (M=2.56; SD=3.18) displaying higher depressive symptomatology compared to the low-risk group (M=1.26; SD=2.08). The effect size of this difference is considered medium (d=-0.48).

There is no difference between the risk groups in how individuals perceive their social support [X^2 (1, *N*=111)=1.30, *p*= .729] or social isolation (LSNS-6) [*t*(109)=0.97, *p*=.335].

Table 3

Sociodemographic characteristics and risk factors for dementia development among groups with low and high risk of dementia

Variables	Low risk		High risk		Statistic test			
	n (%)	*M* (SD)	n (%)	*M* (SD)	X^2	*t*	*p*	*Cohen's d*
Genre								
Female	41 (71.9)		31 (57.4)		2.57		.109	
Male	16 (28.1)		23 (42.6)					
Age	57	64.77 (6.29)	54	64.43 (6.86)		0.28	.782	
Level of education								
Primary Education	13 (22.8)		14 (25.9)					
Middle School	8 (14)		8 (14.8)					
High School	12 (21.1)		17 (31.5)		4.45		.358	
University	24 (42.1)		14 (25.9)					
Doctoral degree	0		1 (1.9)					
Years of education	57	11.77 (4.94)	54	10.91 (4.96)		0.92	.360	
Marital status								
Married	37 (64.9)		37 (68.5)					
Divorced	8 (14)		6 (11.1)		0.60		.897	
Widowed	9 (15.8)		7 (13)					
Single	3 (5.3)		4 (7.4)					
Retirement								
Yes	32 (56.1)		30 (55.6)		0.004		.951	
No	25 (43.9)		24 (44.4)					
LIBRA	57	-2.29 (1.80)	54	1.95 (1.73)		-12.62	<.001	-2.40
GDS	57	1.26 (2.08)	54	2.56 (3.18)		-2.55	.012	-0.48

LSNS-6	57	19.81 (5.73)	54	18.70 (6.28)		0.97	.335
Perception of social support							
No one	0		1				
1 or 2 people	8		6		1.30		.729
3 or 4 people	27		27				
6 or more	22		20				

Note. p<.05

The independent samples t-test was conducted to examine whether there are statistically significant differences between the risk groups regarding their performance on neuropsychological assessment instruments. Table 4 reveals significant differences between the groups' performance in Phonemic Verbal Fluency performance [$t(109)=2.14$, $p=.034$] with a medium effect size ($d=0.41$). Finally, significant differences can be observed between the risk groups in the TeLPI Full-Scale IQ [$t(109)=2.25$, $p=.026$], with a medium effect size ($d=0.43$).

Table 4

Neuropsychological profile of groups with low risk and high risk of developing dementia

Variables	**Low risk**		**High risk**		***t***	***p***	***Cohen's d***
	n	***M* (SD)**	**n**	***M* (SD)**			
ACE-R	57	90.47 (5.31)	54	88.48 (6.94)	1,70	.090	
SDC *(raw score)*	57	49.84 (13.63)	54	46.22 (13.49)	1.41	.163	
TMT							
A *(time)*	57	41.37 (16.88)	54	43.41 (18.79)	-0.60	.548	
B *(time)*	57	96.46 (42.84)	54	96.35 (56.31)	0.01	.991	
SVF *(animals)*	57	17.91 (4.36)	54	17 (4.75)	1.06	.294	
PVF *(total)*	57	48.74 (16.85)	53	42.25 (14.73)	2.14	.034	0.41
WLT							
Immediate total recall	57	28.47 (5.39)	54	26.35 (6.47)	1.88	.063	
Long-delay recall	57	5.82 (2.26)	54	5.35 (2.45)	1.06	.293	
BRIEF-A							
Self-report	57	91.16 (21.77)	53	94.32 (24.83)	-0.67	.505	
Informant report	51	92.02 (21.52)	47	92.64 (24.13)	-0.13	.894	
TeLPI - FSIQ	57	116,61 (10.16)	54	111.14 (15.08)	2.25	.026	0.43

Note. ACE-R: Addenbrooke's Cognitive Examination–Revised; SDC: Symbol-Digit Coding; TMT; Trail Making Test; SVF: Semantic Verbal Fluency; PVF: Phonemic Verbal Fluency; WLT: Word List Test; BRIEF-A: Behavior Rating Inventary of Executive Function – Adult version; TelPI: Irregular words reading test - Full-Scale IQ. *p*<.05

To identify risk factors in individuals, information related to diagnosed clinical conditions was collected, including heart and vascular diseases, cholesterol levels, metabolic disorders, mental health conditions, tumours or cancer, respiratory diseases, neurological disorders, orthopaedic conditions, autoimmune diseases. Most clinical diagnoses of the participants did not exhibit statistically significant differences between the groups, except for cholesterol. The high-risk group demonstrated a statistically significant difference compared to the low-risk group, as indicated by the chi-square test, X^2 (1, N=111) = 10.43, p =.001, with a higher prevalence of individuals with elevated cholesterol levels in the high-risk group (74.1%) compared to the low-risk group (43.9%).

3.2. Hypothesis Testing

H1: Age differences exist in the performance of social cognition instruments, with older participants exhibiting poorer performance than younger participants in both Theory of Mind and Social Norms measures.

In Table 5 it is possible to note that there are no statistically significant differences were found in the performance on the affective Theory of Mind measure (RMET) between the younger participant group (M=21.07, SD=5.63) and the older participant group [M=20.71, SD=4.54; t(109)= 0.364, p=.717]. However, statistically significant differences were observed in performance on the social norms measure (SNQ) between younger and older participants [t(109)=3.50, p<.001], indicating that older individuals had a lower performance (M=14.31, SD=4.43) than younger individuals (M=16.66, SD=2.49). The effect size is considered medium, according to Cohen's d (d=0.66).

Regarding gender, no significant differences were found in RMET performance [t(109)=-1.09, p=.277] or SQN [t(109)=-1.39, p=.168]. However, a one-way ANOVA revealed a significant difference in RMET performance based on educational levels [$F(3,106)$=7.06, p>.001], but not in SNQ performance. Tukey's HSD test for multiple comparisons found that primary education (M=17.81, DP=4.22) significantly differed from high school (M=22.97, DP=4.50; p<.001, 95% CI=[-8.44, -1.86]) and university (M=22.24, DP=4.94; p=.002, 95% CI=[-7.52, -1.32]).

Table 5

T-Test for independent samples: Age differences in performance of Social Cognition measures

	Age group	n	*M* (SD)	*t*	df	*p*	*Cohen's d*
RMET	*55-64*	59	21.07 (5.63)	0.36	109	.717	
	65-75	52	20.71 (4.54)				
SNQ-22	*55-64*	59	16.66 (2.49)	3.50	109	<.001	0.66
	65-75	52	14.31 (4.43)				

Note. RMET: Reading the Mind in the Eyes Test; SNQ-22: Social Norms Questionnaire
$p<.05$

H2: Participants with higher risk of dementia will have poorer performance in social cognition instruments.

In Table 6 it can be observed the t-test for independent samples between the risk group and the social cognition instruments. There are statistically significant differences between the risk groups in the RMET test, which assesses affective theory of mind [$t(109)=2.09$, $p=.039$]. Individuals at high risk of developing dementia had a lower performance ($M=19.87$, SD=5.24) than individuals at low risk of developing dementia ($M=21.88$, SD=4.87). The effect size is $d=0.40$ which is considered a small effect. However, no statistically significant differences are found between the risk groups ($p>.05$) in the performance of social norms questionnaire [$t(109)=-0.25$, $p=.806$].

Table 6

T-Test for independent samples: Differences in performance of Social Cognition measures between low and high risk of dementia development

Variables	Risk of dementia	n	*M* (SD)	*t*	df	*p*	*Cohen's d*
RMET	*Low risk*	57	21.88 (4.87)	2.09	109	.039	0.40
	High risk	54	19.87 (5.24)				
QNS-22	*Low risk*	57	15.47 (3.79)	-0.25	109	.806	
	High risk	54	15.65 (3.65)				

Note. RMET: Reading the Mind in the Eyes Test; SNQ-22: Social Norms Questionnaire
$p<.05$

H3: There is an association between performance in cognitive tests and performance in social cognition tasks.

Table A1 (see appendix A) displays the results of correlation analyses between the administered neuropsychological tests and tests assessing social cognition.

Regarding performance on the RMET test, weak positive correlations are observed with MMSE [$r(109) = .26$, $p = .005$], TMT-B [$r(109) = -.25$, $p = 009$], Phonemic Verbal Fluency [$r(109) = .24$, $p = .012$), WLT immediate total recall [$r(109) = .20$, $p = .035$], Short delay Recall [$r(109) = .26$, $p = .006$], and BRIEF-A Self-Report [$r(109) = .25$, $p = .009$]. Moderate positive correlations are observed with ACE-R total score [$r(109) = .48$, $p < .001$], Digit-Symbol Coding [$r(109) = .35$, $p. < 001$), WLT long term recall [$r(109) = .30$, $p = .001$], TMT-A [$r(109) = -.35$, $p < .001$], SVF [$r(109) = .34$, $p < .001$] and TeLPI Full-Scale IQ [$r(109) = .45$, $p < 0.001$].

Regarding performance on the Social Norms Questionnaire, weak positive correlations are shown with MMSE [$r(109) = .22$, $p = .022$], BRIEF-A self-report [$r(109) = .23$, $p = .017$], and BRIEF-A informant report [$r(109) = .28$, $p = .005$].

H4: There is a significant association between the size of social networks, levels of social isolation, and/or education levels with the risk of developing dementia and social cognition performance.

In Appendix B, Table B1 displays the correlations among LIBRA questionnaire scores and performance on social cognition tests in relation to variables representing risk factors for dementia. LIBRA score is moderately positively correlated [$r(109) = .34$, $p < .001$] with the GDS. While dementia risk has a positive weak correlation with GDS [$r(109) = 0.24$, $p = .012$] and a negative weak correlation with RMET [$r(109) = -0.20$, $p = .04$].

Regarding the affective Theory of Mind measure (RMET), weak positive correlations are noted with the perception of social support [$r(109) = .19$, $p = .047$]. A moderately positive correlation is observed with years of education [$r(109) = .32$, $p < .001$]. Finally, the measure of understanding of social norms (QNS) shows a weak negative correlation with years of education [$r(109) = -.20$, $p = .034$] and a moderately negative correlation with age [$r(109) = -.35$, $p < .001$].

H5: The social cognition performance significantly predicts risk of dementia

Linear regression analyses were conducted to explore the potential of social cognition measures as predictors of dementia risk (cf. Table 7). The dependent variable was the risk of dementia, with social cognition measures serving as the independent variables. While SNQ did not exhibit a significant predictive value for dementia risk, RMET displayed a predictive effect on dementia risk [R^2_{adj} =.034; F(1,108)=3.82; p=.05]. Performance in the RMET had a significant negative effect (β = -.19, p=.05) on dementia risk, suggesting that individuals with poorer performance tend to have a higher risk of dementia. However, this performance explained only 3.4% of the variance associated with dementia risk, 95% CI [-.037, 0].

Subsequently, variables related to dementia risk factors into our model were introduced, including years of education, social isolation (LSNS-6), perceived social support (Toolkit), and depressive symptoms (GDS), as well as neuropsychological instruments associated with dementia risk, such as ACE-R, Symbol-Digit Coding, and TeLPI. However, it was only the addition of GDS that exhibited a significant predictive effect on dementia risk [R^2_{adj} =0.11; F(2,107)=6.44; p=.0002]. RMET performance maintained a significant negative effect (β = -.22, p=.019, 95% CI [-0.040, -0.004]). In contrast, depressive symptoms yielded a significant positive effect (β = .27, p=.004, 95% CI [0.017, 0.083]), suggesting that a greater presence of depressive symptoms is associated with an increased risk of dementia. This model explains 11% of the variance associated with dementia risk (cf. Table 7).

Table 7

Multiple linear regression table between RMET, GDS and risk of dementia

Variables	*B*	SE	β	*t*	*p*	95%CI
Step 1						
RMET	-0.02	0.01	-.19	-1.96	.05	[-0.04, 0]
Step 2						
RMET	-0.02	0.01	-.22	-2.38	.02	[-0.04, -0.004]
GDS	0.05	0.02	.27	2.96	.004	[0.02, 0.08]

Note. CI: Confidence Interval; RMET: Reading the mind in the Eyes test; GDS: Geriatric depression scale.

R^2_{adj} = 0.03 for Step 1; R^2_{adj} = 0.11 for Step 2.

IV. Discussion

The present dissertation aimed to understand the social cognition profile in healthy individuals at risk of dementia and to investigate whether this profile predicts their dementia risk. Consequently, an exploratory cross-sectional study was conducted, assessing a sample of adults between 55 and 75 years old.

4.1. Social cognition and ageing

suggest

4.2. Social cognition and risk of dementia

Another relevant finding in the present study is related to the decline of affective ToM performance in the group at higher risk of developing dementia, meaning there is a difference of this component of social cognition between groups organised according to their dementia risk. Nevertheless, the explanation for this variation is limited, as, following a regression analysis, affective ToM predicts only 3% of dementia risk. This finding highlights the need for further research on the role of affective ToM as a potential risk factor for dementia, despite its apparent preservation with ageing, as indicated by our results. To the best of our knowledge, this study represents the first investigation aimed at examining the association between social cognition and the risk of developing dementia.

In the context of this study, only affective ToM was revealed to be positively associated with perceived social support, suggesting that a higher level of perceived support may be related to better performance in social cognition. According to Kelly et al.'s meta-analysis (2017), authors indicate that both a low number of social networks and low perceived support are associated with cognitive function deterioration. These data suggest that perceived good social support can be a protective factor against the decline in social cognition, specifically affective ToM, and overall cognitive deterioration.

It is worth noting that our data did not reveal any correlation between perceived social isolation (measured by the number of social networks or the perception of social support) and the risk of dementia. In the literature, although loneliness and social isolation have been recognised as risk factors for cognitive decline and social cognition (Lisko et al., 2020; Lewis et al., 2011), there are conflicting results, with some authors indicating social isolation is associated with dementia risk and the deterioration of brain areas

involved in cognition (Elovainio et al., 2022; Shen et al., 2022), while others suggest that only loneliness (but not social isolation) is effectively associated to dementia risk (Freak-Poli et al., 2022; Salinas et al., 2022). This finding may be attributed to several potential explanations, some of which could be linked to methodological issues. According to the literature (Morese & Palermo, 2022; NASEM, 2020), retirement and the loss of companions can exacerbate social isolation. In our study, a significant proportion of respondents (44.1%) were still employed. NASEM (2020) also highlights that the retirement period is a critical phase of transition, which can proceed favourably or not, depending on the individual and the environment. During this phase, there is a risk of losing social support and friendships due to the exit from the workplace and experiencing social isolation. Being employed could act as a protective factor against this isolation. In this context, given that nearly half of the individuals in our sample are employed, it is plausible to infer that they have more frequent contact with others and enjoy greater companionship. Consequently, it is possible that the measure of social isolation used may not have accurately captured the level of social isolation among these individuals. It would have been beneficial to consider factors like the person's physical health, functional abilities, sensory impairments, social engagement, and changes in income, as these are also known to influence social isolation and loneliness (Czaja et al. 2021; Morese & Palermo, 2022; NASEM, 2020). Furthermore, it's worth noting the potential impact of social desirability bias, as the LSNS-6 questionnaire was administered through an interview.

Regarding dementia risk, in our study, the LIBRA score was associated with lower premorbid intellectual levels and greater depressive symptomatology. This association of higher dementia risk with a lower premorbid level (Cervilla et al., 2004; Pavlik et al., 2006; Quattropani et al., 2021) and greater depressive symptomatology (Cantón-Habas et al., 2020; Livingston et al., 2020; Lisko et al., 2020) aligns with the existing literature. Notably, the significant role of depressive symptoms in dementia risk is highlighted, as it accounts for approximately 11% of the dementia risk when incorporated into the regression model along with affective Theory of Mind (ToM). According to the literature, depressive symptoms should be closely monitored due to their strong association with an increased risk of dementia. Two meta-analyses have indicated that depression doubles the likelihood of developing dementia (Kessing et al., 2012). In this regard, Hakim (2022) emphasises the importance of preventing and treating depression to mitigate its cognitive

impact, highlighting the effectiveness of antidepressant medication and high-quality social support.

The decline associated with depression is not limited to cognitive functions but also extends to social cognition. It is consistent in the literature that individuals with depressive symptomatology tend to experience impairments in both affective and cognitive ToM, and this decline worsens with the severity of symptoms. In their meta-analysis, Nestor et al. (2022) propose three explanations: firstly, individuals may be overwhelmed by their negative thoughts, leading to a failure to pay attention to the mental or emotional states of others; secondly, individuals with depression tend to withdraw from social interactions and activities, which has been linked to serious consequences for cognitive function and deterioration (Porcelli et al., 2019; Nestor et al., 2022); and thirdly, there may be abnormalities in the neural networks associated with ToM, both structurally and functionally (Nestor et al., 2022).

4.3. Considerations for future research

A comprehensive assessment of social cognition profile would greatly enhance future research efforts aimed at exploring the variations in the preservation or decline of different aspects of social cognition in both normal ageing and individuals with varying degrees of risk of dementia. The protocol assessment can encompass a multitude of dimensions, including social perception, which can include the recognition of facial expressions, body language, and vocal changes (Arioli et al., 2018; Voos et al., 2013); both affective and cognitive ToM while considering first-, second-order beliefs, as well as emotional resonance or contagion, in order to evaluate the processes of the MNS (Arioli et al., 2018), empathy (Beadle et al., 2019) and understanding of social norms (Ganguli et al., 2018).

The age-related decline associated ToM remains a subject of controversy, with some authors suggesting that the observed contradictions in studies may be attributed to the heterogeneous methodologies employed. In this regard, it is essential that the evaluation of these components is conducted within the same modality (visual or verbal), while also comparing different levels of difficulty, such as first- and second-order belief reasoning (Henry et al., 2013; Ruiternberg et al., 2020). Utilising The Awareness of Social Inference Test-Short (TASIT-S; McDonnald et al., 2006) offers several advantages. It not only allows for the standardisation of assessment methods for both

affective and cognitive Theory of Mind (ToM), providing valuable insights, but also facilitates the evaluation of social perception by assessing the recognition of facial expressions, prosody, and gestures. TASIT-S comprehensively covers both second- and first-order components of ToM and assesses the comprehension of sarcasm and non-literal comments, all of which are presented through video performances by actors (Eddy, 2019; McDonnald et al., 2006). Furthermore, it's worth noting that while the full version of TASIT can take more than 60 minutes to complete, the shorter version can be administered in approximately 30 minutes, making it a more efficient option for research purposes (Honan et al., 2016). Another significant advantage of TASIT-S is that it is considered a tool with good ecological validity, allowing for the assessment of various facets of social cognition in a more naturalistic context. In the real world, people infer the intentions and emotions of others based on facial expressions, tone of voice, nonverbal language, and contextual cues. Therefore, assessing only one of these components in isolation in a research or laboratory setting may not be sensitive enough to detect deficits in the interpretation of complex social information that enable individuals to adjust their behaviour according to the situation (Martin et al., 2022).

Examining empathy is also pertinent due to its association with loneliness and depression, and the need to clarify how age affects its bio and psychological mechanisms (Beadle et al., 2019). One suggestion would be to assess it using the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers et al., 2011), as it accounts for both cognitive and affective components. It also considers five dimensions important for the understanding of empathy like emotion contagion (mirroring others' emotional states), proximal responsivity (emotional reactions to those close to the individual), peripheral responsivity (emotional reactions to emotions or moods of distant individuals), perspective taking (the ability to infer from another's perspective), and online simulation (the capacity to imagine oneself in another's situation) (Queirós et al, 2018).

Similarly, it is important to note that our assessment solely measures intrapersonal social norm comprehension (the ability to perceive if one is adhering to norms in a given context) and does not encompass interpersonal norms (the ability to perceive if others are adhering to norms) (Baksh et al., 2018; Isernia et al., 2022). The Edinburgh Social Cognition Test (ESCoT; Baksh et al., 2018) can be utilised to assess both cognitive and affective Theory of Mind, as well as interpersonal and intrapersonal understanding of social norms through animations. The administration of this instrument typically takes

between 20 to 25 minutes and is considered a robust ecological measure (Baksh et al., 2018).

Regarding the sample size, it is crucial to ensure that it is appropriately sized to account for the number of comparisons and statistical analyses conducted. Additionally, the sample should encompass a broad age range to facilitate comparisons among individuals in the three stages of ageing: 65-74 years are considered the young-old; 75-84 years are middle-old, and those aged 85 years and older are categorised as the old-old (Cohen-Mansfield, 2013).

Within this framework, integrating these comprehensive assessment tools into future research can offer a more comprehensive insight into social cognition in normative ageing and within the context of dementia risk. This includes various processes such as social perception, embodied cognition, mentalising, understanding of social norms, and empathy. Such an approach would be crucial for understanding the mechanisms involved in the decline or preservation of these processes and for comprehending the potential consequences that may manifest in individuals' daily lives. This understanding extends to issues like inappropriate behaviour due to a failure to grasp social and contextual cues, as well as the inability to discern sarcasm or insincerity in others which can lead to an increased vulnerability to deception and have significant implications for individuals' day-to-day interactions and well-being.

4.4. Limitations

The present research has limitations that need to be considered alongside the results.

This is an exploratory study that focuses on an innovative and not yet investigated subject, with the primary goal of formulating research hypotheses. In this context, the statistical methodology employed was less conservative; we did not control variables and did not apply the Bonferroni correction to reduce the likelihood of Type I errors. The sample was recruited using a convenience sampling approach, which suggests that the results may not be representative of the general population. Due to this approach, women were more willing to participate, resulting in a predominance of females in the sample (64.9%) and most participants have a university-level education (34.2%). Additionally, it's important to acknowledge the sample size, which is considered small given the number of group comparisons conducted during the statistical analysis of the data. A

power analysis should be conducted in future studies to account for multiple variables to be compared.

Moreover, it is also worth noting as a limitation that the categorisation of risk groups was only based on LIBRA scores, and this measure only considers modifiable risk factors, excluding non-modifiable risk factors. While modifiable factors can predict up to 40% of dementia risk, it is crucial to analyse the overall dementia risk comprehensively. Non-modifiable factors such as age, gender (particularly being female), educational background, genetic predisposition, and a family history of dementia play significant roles (Anstey et al., 2022; Lisko et al., 2020). There are additional modifiable factors, such as a history of head injury, exposure to air pollution, and levels of social engagement, as highlighted by Anstey et al. (2022a) and Livingston et al. (2020), which are not taken into account by LIBRA. Incorporating the modified version of LIBRA that also includes age, gender, and education in the assessment (Huque et al., 2023) could significantly enhance the accuracy of dementia risk evaluation. Alternatively, the introduction of the Cognitive Health and Dementia Risk Index (CogDrisk) could offer a more comprehensive approach (Anstey et al, 2022b; Huque et al., 2023). CogDrisk encompasses 17 risk factors, including age, gender, education, obesity, high cholesterol, diabetes, depression, insomnia, traumatic brain injury, smoking habits, feelings of loneliness, physical activity levels, cognitive engagement, history of stroke, atrial fibrillation, dietary habits, and hypertension. According to Huque et al. (2023), CogDrisk may prove to be a more informative tool in assessing dementia risk compared to other instruments like LIBRA or the Cardiovascular Risk Factors, Aging, and Dementia (CAIDE) risk score.

There are certain limitations to the social cognition instruments that were utilised. The RMET images, which were in black and white and had low resolution, did not represent diverse ethnicities (Baron-Cohen et al., 2015; Bianco, 2020). Additionally, the SNQ-22, originally adapted for the United States population and known to be influenced by cultural factors, wasn't yet fully adapted, and validated for the Portuguese population, only translated.

As mentioned before, another important limitation to highlight is that the present study only addressed certain aspects of social cognition, such as social norms understanding and affective ToM but not cognitive ToM or empathy. An in-depth assessment of social cognition would be a valuable addition to future studies. The protocol could benefit from the inclusion of: TASIT, which assesses social perception,

affective and cognitive ToM, and understanding of non-literal comments (Eddy, 2019; McDonald et al., 2006); the QCAE measures cognitive and affective empathy, as well as other dimensions like emotion contagion, proximal responsivity, peripheral responsivity, and perspective taking (Reniers et al., 2011); and the inclusion of ESCoT could aid in evaluating intra and interpersonal understanding of social norms (Baksh et al., 2018).

Regarding the assessment procedures, the length of the neuropsychologic protocol used may have also negatively affected participants' performance and motivation, primarily due to fatigue, which could have adversely impacted individuals' scores. The protocol employed in this study was part of a larger dementia prevention study and included additional instruments that are not relevant to the analyses conducted for the specific topic of this study. Therefore, a future study should only include the interview, neuropsychological assessment tools evaluating memory, processing speed, and executive functions, as well as the previously mentioned measures of social cognition. As it is also essential to acknowledge the possibility of social desirability bias, given that most of the questionnaires were conducted in an interview format, certain questionnaires, such as the GDS-15, LIBRA, SNQ-22, and LSNS-6 could be completed using an online platform that enables them to submit their responses while ensuring anonymity. This strategy could help mitigate this bias by minimising the personal nature of the response method and ensuring confidentiality that informed consent alone does not provide. Another approach would also involve soliciting assessments from individuals close to the subject to provide an external evaluation.

For future research, it is advisable to extend the data collection period to enable gathering a larger randomised sample, thus enhancing the external validity of the results through population representativeness. This will also increase statistical power, allowing for the detection of genuine differences and the production of generalised and meaningful outcomes. As previously mentioned, the protocol should be reduced or provide the option to divide its application. Furthermore, it would be beneficial for forthcoming research to explore various facets of social cognition and potentially incorporate a longitudinal study design. This methodology would facilitate an analysis of significant patterns and changes over time, offering insights into how certain factors, such as depressive symptomatology and social isolation, may influence social cognition at different life stages.

V. Conclusion

The present exploratory study sought to contribute to research on dementia risk, considering two components of social cognition: affective ToM and understanding of social norms. It is important to note that the study is exploratory in nature, yet its findings hold potential utility for future research in this field. The study provides current and relevant data on social cognition, a relatively understudied area, particularly in older adults at risk of dementia but without cognitive decline. The insights gained from this study may prove valuable in advancing scientific knowledge in this field.

Using a quasi-experimental methodology, the study found that the understanding of social norms declines with age but does not vary significantly based on dementia risk. Affective ToM, on the other hand, shows no age differences and may be a potential indicator of dementia risk, as it differs based on dementia risk. However, this difference only explains 3% of the proportion of the dementia risk in the sample, which only increases to 11% when depressive symptomatology is taken into account.

Moreover, the study highlights the role of depression in the risk of dementia and social cognition. Depression significantly increases the risk of developing dementia and is associated with deficits in affective theory of mind. This link highlights the importance of addressing and treating depression as a preventive measure against cognitive and social cognitive decline.

The study also underscores the importance of social factors, such as perceived social isolation and social support, in the performance of affective ToM, which should be considered when preventing cognitive and social decline. Additionally, the research demonstrates the interconnectedness of various aspects of cognition, showing that social cognition is intrinsically linked to other cognitive functions, such as memory, information processing, and executive cognition. Thus, social cognition alongside cognitive abilities can be crucial for a comprehensive understanding of ageing and the risk of dementia. This provides insight into the complex nature of cognitive ageing and highlights the need for a multidimensional approach to assessing cognitive capacity. By considering the interplay between these, we can develop more effective strategies for promoting healthy ageing and preventing dementia.

The findings of this study have significant clinical implications, particularly in the development of targeted interventions for cognitively healthy individuals at risk of

dementia. The focus should extend beyond solely enhancing or maintaining cognitive and social cognitive abilities, to also include a focus on the mental well-being of individuals. Improving perceived social support and considering the quality of relationships of the individuals should also be a priority in these interventions.

In conclusion, this study provides a valuable starting point for further investigations into the interplay between social cognition and dementia risk in older adults. By continuing to explore these relationships, researchers can contribute to the growing body of knowledge in the field of dementia research and potentially inform interventions that promote healthy ageing and reduce the risk of cognitive decline in older populations.

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Appendices

Appendix A: Correlation Matrix

Table A1

Correlation matrix between neuropsychological instruments, social cognition instruments and dementia risk

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. MMSE	1															
2. ACE-R	.53***	1														
3. SDC	.25**	.51***	1													
4. TMT-A	-.22*	-.44***	-.43***	1												
5. TMT-B	-.23*	-.25**	-.49***	.56***	1											
6. SVF	.31***	.60***	.36**	-.32***	-.25**	1										
7. PVF	.41***	.45***	.36***	-.15	-.20*	.45***	1									
8. WLT-I[a]	.25**	.39***	.34***	-.05	-.06	.42***	.44***	1								
9. WLT-I[b]	.15	.41***	.25**	-.16	-.10	.29**	.24*	.68***	1							
10. WLT-II[c]	.20*	.42***	.29**	-.19*	-.08	.32***	.24*	.64***	.80***	1						
11. BRIEF-A[d]	.06	.08	.09	-.08	-.01	.13	.07	-.06	.19*	.12	1					
12. BRIEF-A[e]	.04	-.01	.14	-.03	-.02	.06	-.04	-.02	-.02	-.07	.59***	1				
13. TELPI	.17	.44***	.356***	-.38***	-.31***	.32***	.21*	.25**	.13	.23*	.08	.18	1			
14. LIBRA	-.17	-.20*	-.23*	.12	.15	-.15	-.33***	-.20*	-.05	-.07	.17	.13	-.23*	1		
15. RMET	.26**	.48***	.35***	-.35***	-.25**	.34***	.24*	.20*	.26**	.30***	.25**	.13	.45***	-.15	1	
16. QNS-22	.22*	-.05	.02	.05	.08	-.09	-.04	-.02	.01	.05	.23*	.28**	-.096	.03	.19	1

Note. MMSE: Mini Mental state examination; ACE-R: Addenbrooke's Cognitive Examination–Revised; SDC: Symbol-Digit Coding; TMT: Trail Making Test; SVF: Semantic Verbal Fluency; PVF: Phonemic Verbal Fluency; WLT: Word List Test[abc]; BRIEF-A: Behavior Rating Inventary of Executive Function – Adult version[de]; TelPI: Irregular words reading test– Full-Scale IQ; LIBRA: Lifestyle for Brain Health; RMET: Reading the Mind in the Eyes Test; SNQ-22: Social Norms Questionnaire-22.

[a] immediate total recall; [b] short-term recall; [c] long-term recall; [d] self-report; [e] informant report.

* $p < .05$ ** $p < .01$ *** $p < .001$

Appendix B: Correlation Matrix

Table B1

Correlation matrix between social cognition instruments, dementia risk, and assessed risk factors for dementia

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Perception of social support	1								
2. Years of education	.11	1							
3. Age	.06	.19	1						
4. GDS	-.28**	.09	.227*	1					
5. LSNS-6	.47**	.14	.01	-.39***	1				
6. LIBRA	-.07	-.17	.04	.34***	-.14	1			
7. Dementia risk	-02	-.09	-.02	.24***	-.09	.77***	1		
8. RMET	.19*	.32***	-.04	.13	.01	-.15	-.20*	1	
9. SNQ-22	.02	-.20*	-.35***	-.04	-.04	.03	.02	.19	1

Note. GDS: Geriatric Depression Scale; LSNS-6: Lubben Social Network Scale-6; LIBRA: Lifestyle for Brain Health; RMET: Reading the Mind in the Eyes Test; SNQ-22: Social Norms Questionnaire-22.

* $p < .05$, ** $p < .01$, *** $p < .001$