Investigation of the association between social cognition and social functioning in aging.

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Declaration

This thesis contains original and unique material which has not been used to obtain any other degree in any institution. All experiments and analyses were computed by no other than me. To the best of my knowledge and belief, it does not contain any material previously published or written by another person, except where due reference is made. I played a prominent role in writing and editing the manuscripts across all studies, while receiving guidance from co-authors during the drafting and revision stages.

Acknowledgments

My PhD journey began in the most unusual circumstances, amidst a global pandemic and lockdown, from the 'comfort' of my home - as far away from the department and lab as possible. I had chosen to research older adults' social behaviors during a period of necessary social distancing, where they were identified as the most at-risk individuals. All of this at a university located in the most affected place of all Europe. It goes without saying that the first year of this PhD was no walk in the park. However, thanks to the incredible supervision team in Pavia, we successfully navigated this additional challenge the world had to face, by keeping things rolling and studying older adults social functioning in an interactive and ecological manner.

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RESEARCH OUTPUTS

1. PUBLICATIONS IN PROGRESS BASED ON THIS THESIS

Florkin, A.L., Gatti, D., Lecce, S. & Cavallini, E. (2023). Age-related differences in theory of mind, the potential role of the task domain, task modality, ecological validity, or the perspective of the respondent: meta-analytic review.

Florkin A.L., Rosi, A., Lecce, S. & Cavallini, E. (2023). Cognitive functions, theory of mind abilities, and personality dispositions as predictors of the detection of reciprocity in deceptive and cooperative contexts through different age-groups.

Florkin A.L., Rosi, A., Lecce, S. & Cavallini, E. (2023). An interactive approach showing the association between social functioning and theory of mind in aging.

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2. CONFERENCE PRESENTATIONS

Florkin A.L., Rosi, A., Lecce, S. & Cavallini, E., *Valutare la reciprocità nell'invecchiamento attraverso un compito ecologico e interattivo: l'Interactive Drawing Task,* Convegno nazionale di psicologia dell'invecchiamento XVI, Società Italiana di Psicologia dell'Invecchiamento (SIPI), 26th of May 2023

3. POSTERS

Florkin A.L., Rosi, A., Lecce, S. & Cavallini, E., *An interactive approach showing the association between social functioning and theory of mind in aging,* 2023 International Convention of Psychological Science (ICPS), Association for Psychological Science (APS), 11th of March 2023

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CHAPTER I. Thesis overview

1. THESIS RATIONALE

A main world challenge in the last decades has been demographics due to the increase in life expectancy in multiple countries. The world population is aging. For example, European citizens gained on average 2.5 years of life expectancy between 2002 (M=77.6 years) and 2021 (M=80.1 years) (Eurostat, 2023). Unfortunately, growing old comes with its own set of challenges, such as hearing loss, memory decline, decreased mobility, cognitive impairments sometimes to a pathological state, isolation, social impairments, etc. The new challenge is to expand the number of qualitative (i.e., healthy and functional) years, along with the increase in life expectancy.

1.1. Successful aging

As a consequence, research investigated ways to maintain a healthy and successful aging process and extensively focused on cognitive and physical decline. However, it did not pay as much attention to the more social aspects of life, even though older adults can become more dependent on others which creates situations for which social skills remain handy. Only more recently did research start to investigate social functioning and cognition in older age. Rowe and Kahn (1997) highlighted that the concept of successful aging did not only rely on a preservation of physical and cognitive abilities but on the association of these two factors with an active lifestyle with regards to interpersonal relationships. In sum, they defined successful aging as an unimpaired physical, psychological, and social functioning.

A qualitative study of Jopp and colleagues (2015) established that the second recurring theme, just after health, that was related or contributed to successful aging, according to a cohort of individuals aged between 15 and 96 years, was social resources, such as social network and social engagement. Nonetheless, older people seem to have smaller social networks, interact less with others, especially strangers, and to not specifically want to put more effort into

creating new social relationships (Carstensen et al., 2003). The socioemotional selectivity theory states that social motives change with age and that older adults reward qualitative interactions over the quantity of interactions. Older adults cultivate the social exchanges with close relatives, such as spouses, children and siblings, and close friends, reducing contacts with peripheral social partners, and are satisfied with their social interactions. On the other hand, this reduction of interacting partners and social exchanges could hinder older adults' social functioning.

1.2. Social functioning

Therefore, could it be that older adults lower their interactions due to a decrease in social functioning or, on the contrary, that their lower social contacts create a decrease in social functioning? Social functioning measures how well we adapt to our social environment (Bosc, 2000) and is defined as the ability to adequately keep, engage, and reciprocate daily social encounters and connections (Bottema-Beutel et al., 2019; Hirschfeld et al., 2000). A focus is set on the word reciprocity in the definition. Reciprocity is indeed a fundamental concept of social functioning. It is a continuance of joint and appropriate social behaviors between interacting individuals (Moore and Baressi, 2017; Voelkl, 2015). Little is known about reciprocity in older adults. Only a few studies considered the concept of reciprocity in aging: some of them evaluated the age difference in the ability to detect reciprocity whereas others examined the perception of reciprocity. Calso and colleagues (2019a, 2019b) found that older adults had more difficulties to detect reciprocity than younger adults. Additionally, Braun and colleagues (2018) demonstrated that perceived reciprocity was lower in older adults than in middle-aged adults, but that relationship satisfaction was not altered by age. In line with the socioemotional selective theory, older adults valued perceived reciprocity more in close relationships than in peripheral ones. However, these studies do not inform on the ability of older adults to reciprocate.

Most studies on social functioning in aging do not focus on the factors involved in social functioning, nor do they assess real performance. They investigate the link between social functioning and social cognition because, in order to preserve social functioning, it is crucial to understand and predict other individuals' social behavior. Social interactions rely on the understanding of mental states, i.e., to attribute beliefs, desires, and emotions to other individuals, in other words to preserve Theory of Mind (ToM). Bailey and colleagues' (2008) research on empathy and social functioning revealed that the lower abilities of older adults to understand and infer mental states to others was partially responsible for the age-related decline in social functioning. Although this study informs us on a likely effect of social cognition on social functioning, social functioning was, once again, assessed through a self-report questionnaire in this study.

A. Social cognitive abilities

There is thus reason to believe that a decline in social cognitive performance could be responsible for a decline in social functioning abilities. Social cognition is defined as an essential competence to engage in social exchanges and comprehend social interactions (Beaudoin & Beauchamp, 2020). This social cognitive skill is composed of three abilities, namely, emotion recognition, ToM, and empathy. However, in this thesis we will study social cognition through the scope of ToM abilities.

ToM has been studied in older adults since the 1990s. Importantly, older adults have showed lower ToM performances in comparison to younger adults in multiple studies (Henry et al., 2013). Moreover, the meta-analysis of Henry and colleagues (2013) supported the idea that the lower performances in ToM in older adults was not linked to the operationalization of ToM. In fact, ToM is a multimodal concept assessed through various dimensions (for a broader discussion of the concept of ToM, see section 1).

A distinct competence of ToM that we highlight here and in which older adults have demonstrated various difficulties is perspective-taking. Studies' findings indicated that older adults had a stronger egocentric bias, making it more difficult for them to switch from the self to the other perspective (Martin et al., 2019). This is an important outcome because a higher perspective-taking has been found to increase reciprocal behaviors in adolescents (Fett et al., 2014).

In another vein, a new review of Henry et al. (2023) proposed that capacity, motivation, context, and the interaction of these determinants, sometimes disregarded in lab tasks, could enhance the age loss in ToM performance in lab settings contrary to real life.

B. Second-person approach

A major critique on studies of social interactions is that they are assessed in social observation and neglect the interacting factor of social contacts. In fact, three different perspectives can be taken in an interaction: the first-, the second- and the third-person perspective. All three perspectives are important to understand deliberate interactions (Moore & Barresi, 2017). The first-person perspective appeals to our own experience of an interaction during a social encounter. It is seen as the simulation theory, where the first-person experience is used as a model for understanding others' mental states, point of views, or more generally social behaviors. The third-person perspective emphasizes the observational stance on an interaction. This perspective is called a theory-theory approach, where individuals theorize social knowledge and adopt an observational stance to interpret the other person's social behaviors. Finally, the second-person perspective stresses the diverse experience of engaging in an interaction. This approach is also known as the interaction theory which states that direct interaction between people provide the context and the conditions to understand others' social actions. In a social interaction, we adopt all three perspectives, we are observing, experiencing, and participating at the same time. We thus analyze the others' behavior (third-person

observational stance), we experience our own actions (first-person simulation) and we interpret the interdependence of these behaviors (second-person interaction), which leads us to correctly evaluate the interaction and respond adequately. For example, if a misunderstanding occurs, an individual has to rethink their own interpretation of the situation (first person), understand the perception of the other (third person) and explain the interaction of intentions (second person). Assessing social functioning is difficult in non-interactive contexts. Proof of this is the definition of reciprocity, which is the action to answer to a social behavior in a balanced and suitable manner. Therefore, a social behavior should be addressed to you so you can respond to it. This is a big gap in the present literature.

2. THESIS AIMS

In conclusion, the literature provides very few studies on the social functioning ability of older adults. Social functioning is often studied in relation to social cognition, although mainly under the form of self-report questionnaires, or it is merely seen as social interaction. When an association between social functioning and social cognition is explored, researchers often address the decline in social functioning as a predictor of the decline in ToM (e.g. Gourlay et al., 2021). According to Bailey and colleagues (2008), this association is bidirectional: not only is it possible that a lower social functioning can affect social cognition but, as they demonstrated, an age-related decrease in ToM performance can also be partially responsible for a lower social functioning. However, as previously stated, most research studies social functioning through self-report questionnaires. Consequently, social functioning, along with other social concepts, is studied in an observational or simulation stance and thus individuals are asked to take a third- or first-person perspective to respond to the tasks. More recently, participants have been placed in a second-person perspective with new interactive tasks such as empathic accuracy tasks (Fujiwara & Daibo, 2021) or the interactive drawing task (Backer van Ommeren et al., 2017).

After considering these different gaps in the literature, this doctoral thesis aims at exploring several hovering questions:

1) Do older adults have a lowered social functioning, assessed through reciprocity, compared to younger adults?

2) If there is an age-related decline in social functioning, does a lowered social cognition, more specifically in ToM abilities, partially or completely explain this decrease in capacity?

3) Is social functioning predicted by social cognition more generally in aging?

4) Does the approach of the task affect the age-related differences in social cognition and functioning?

3. THESIS STRUCTURE

3.1. Section I. Social cognition in healthy aging

This thesis starts with a section on social cognition in aging. It consists of two studies: a meta-analysis and a study on spontaneous perspective taking. It is important to start this thesis with a review of the age-related decline in social cognition, especially in ToM, to have a clear idea on the age effects of ToM performance before we explore the possibility for the decline in ToM to moderate the decline in social functioning.

A. Study 1: Meta-analysis

In the last years, a lot of interest has been granted to ToM in older adults and the possible age-related differences that can result from it. Additionally, several new approaches on ToM, such as the aforementioned second-person approach, have been incorporated to these studies. Nevertheless, the last meta-analysis investigating age differences in ToM is dated from 2013. It is thus interesting to verify if the results of this last meta-analysis (Henry et al., 2013), stating that the age decline was independent from the task parameters, are still relevant today before testing if age-related deterioration in ToM is predictive of a decline in social functioning. This

study aims at exploring if the approach and the parameters of the task affect the age-related differences in social cognition.

B. Study 2: cultural and age-related differences in spontaneous perspective-taking

Another important problem in older adults is the distinction between self and other perspective. Being able to take another's perspective is crucial in social interactions since every perspective of an exchange is analyzed to comprehend it and react properly. Moreover, as specified in the rationale of this thesis, the review of Henry and colleagues (2023) pointed out that cognitive capacities and motivation could worsen the older adults' performance. Therefore, we decided to assess a more automatic and ecological, as well as less cognitively demanding ability, with a spontaneous perspective-taking task. With this study, we intend to examine the effect of the approach of the task on age-related differences in social cognition.

3.2. Section II. The association between social functioning and social cognition

This second section pertains to our other aims. After assessing social cognition in aging, we will finally look at social functioning abilities and the association between social functioning and social cognition. This section again comprises two studies: cognition, personality, and ToM as predictors of reciprocity and an interactive approach in reciprocity showing the association with ToM.

A. Study 3: The predictive roles of cognition, personality, and ToM on reciprocity

In this third study, the concept of social functioning is introduced and assessed through the detection of reciprocity. This study focuses on the detection of three aspects of reciprocity, namely deception, cooperation and cheating in a cooperative and deceptive context, through a task assessing simultaneously true and false belief understanding. The goal is to study the age-related differences in reciprocity detection and test if several aspects like cognition, personality, and ToM abilities are predictors of the reciprocity dimensions. Thus, this study attempted to

evaluate the broader aim of age-related decrease in social functioning performance and the association between social cognition and social functioning.

B. Study 4: An interactive approach in reciprocity showing the association with ToM

This last research encompasses various aspects of the former presented studies. Social functioning is assessed here through an implicit interactive task eliciting reciprocity. For the study, older adults worked together with the experimenter on a common acitivity, i.e., drawing together. Beside their performance, their beliefs on reciprocity are reviewed, together with their ToM abilities in various ToM tasks. The objective is to compare younger and older adults' performance in reciprocity as well as their beliefs and ToM abilities. A second objective is to estimate the impact of their beliefs on their reciprocity performance and the effects of cognition and ToM capacities on the age decline in reciprocity. Finally, we aspire to explore in which way the diverse ToM measures could likely be linked to reciprocity in the different age groups. Overall, this last study tries to analyze the main aims of this thesis, namely the age-difference in social functioning, the association between the diminished ToM capacities in older adults and the age deterioration in reciprocity, the association between ToM and reciprocity in older adults, as well as the effect of a more social approach on the decline in reciprocity.

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SECTION 1. Social cognitive changes in healthy aging

Chapter II. *Section guide*

Theoretical issues

Social cognition is a set of crucial mental abilities to participate, decipher and apprehend social interactions, allowing us to perceive, treat and make sense of social incentives (Beaudoin & Beauchamp, 2020). It consists of three main aspects: emotion recognition, Theory of Mind (ToM) and empathy. This thesis will focus on the essential notion of ToM.

The concept of Theory of Mind (ToM) was popularized by Premack & Woodruff (1978) during a study on chimpanzees' ability to infer mental states to humans. After that it became a hot topic in the developmental psychology field. The first study on age-related differences in ToM involving older adults was administered by Happé and colleagues (1998). Their results demonstrated that older adults had a greater ability than younger adults to appropriately infer mental states to story characters. Since then, many others have researched the subject, but these results were not replicated. The literature either showed a decline in older adults, or no age-related differences between younger and older adults. In 2013, Henry et al. published a meta-analysis to have an overview of the data concerning age-related differences between younger and older adults in ToM. They concluded that the age-related decline was not dependent on the task parameters of ToM assessment.

Indeed, ToM is a multimodal concept measured under various distinct dimensions. For example, the task can be cognitive or affective. The cold aspects of ToM, called cognitive ToM, infer mental states on thoughts, beliefs and intentions, whereas the hot aspects of ToM, otherwise known as affective ToM are focused on interpreting emotions and feelings. Some tasks are mainly cognitive like the False belief (FB) task which measures the ability to grasp that individuals' mental representation of reality can diverge and that some can hold an inaccurate portrayal of a situation. Other tasks are more affective, like Reading the Mind in the eyes (RMET, Baron-Cohen et al.,2001), where a person must reckon a feeling by looking at

pictures of the eyes part of human faces. Then some tasks can be a mix of hot and cold aspects of ToM like the Strange stories of Happé et al. (1994), where a situation of faux pas, white lies, persuasion, or double bluff is depicted in a story. It assesses the capacity to infer mental states to a story character by judging the situation. According to Wang & Su (2013) older adults showed more difficulties in cognitive ToM compared to affective ToM.

Various other categories of task exist. Perspective-taking, for example, estimates a person's ability to take the perspective of another person or to switch between their own perspective and the perspective of another. Older adults have demonstrated a tendency to prioritize their own perspective over the perspective of the other (Mattan et al., 2017), along with a greater difficulty to switch between the self-perspective (first person) and the other-perspective (third person) (Martin et al., 2019). As mentioned in the rationale of this thesis, social interactions require to take a first-, second- or third- person perspective, which is reflected in the tasks. A participant can be required to take any of these perspectives to perform a task.

A second way tasks may also vary is in the way they present their stimuli. It can be verbal or visual, static or dynamic. Furthermore, a task can be explicit or implicit (Sabbagh & Bowman, 2018). Explicit tasks clearly express their request and demand deliberate and conscious answers, while implicit tasks are non-declarative and lean on automatic and natural responses. Explicit tasks are seen as more cognitively demanding and it is therefore interesting to test more natural and spontaneous reactions. Besides, Cho and Cohen (2019) used an implicit FB ToM task in their studie and discovered no age-related differences between younger and older adults. They pinned the age differences on diminishing executive functioning.

These are all the different elements that will be investigated in these different chapters. Based on the findings supporting that task operationalization plays a role in age-related decrease in ToM performance, Chapter III will reevaluate the literature in the field by conducting a meta-

analysis on age-differences in older adults. Chapter IV will look at the spontaneous evaluation of another person's perspective, targeting the difficulty of older adults to distinguish other- and self-perspectives.

Main measure

Spontaneous perspective-taking task (SPT)

The SPT is a new task created by the department. It is a second level uncued perspective-taking task, inspired by previous spontaneous tasks used in research (Tversky et Hard, 2010, Quesque et al., 2018). For example, the participants are shown a picture of an object in front of a person and are asked where the object is situated. The aim of the task is to spontaneously trigger an egocentric or alter-centric perspective tendency. The SPT simulated everyday life experiences where we are brought to take multiple unsolicited point of views to best react to a social situation.

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Chapter III. Study 1 – Age-related differences in Theory of Mind, the potential role of the task domain, task modality, ecological validity, or the perspective of the respondent: Meta-analytic review

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1. ABSTRACT

The literature on social cognition and more specifically on Theory of Mind (ToM), regarding age-related differences, has risen in the last decades. Moreover, several conceptual changes have been implemented, making ToM into a multimodal concept. A first meta-analysis was conducted by Henry and colleagues in 2013 and highlighted that the age-differences in ToM were independent of the parameters of the task. We decided to investigate if an updated meta-analysis, enriched with new papers and approaches on the matter, would lead us to draw the same conclusions. The aim of this meta-analysis was thus threefold: 1) evaluate the age-related ToM difficulties, 2) test if the found age-related differences are specific to ToM, and 3) verify if some covariates could moderate the age effects such as the task type, the domain, the modality, the ecological validity, and the perspective of the respondent. Finally, 64 papers combining 110 ToM tasks were included in this multivariate meta-analysis. The outcomes outlined an overall age-related decline with no moderator effects of any of the covariables, consistend with the observation of the previous meta-analysis. Moreover, a great variance was found between the ToM tasks confirming that ToM is a multimodal concept where the task measures different components but outlining that older adults have a difficulty in the overall concept of ToM. Furthermore, this study highlighted that ToM performance is essentially researched in an observational stance with poor ecological validity.

Keywords: Theory of Mind, multivariate meta-analysis, mental states, aging

2. INTRODUCTION

Individuals' lifespan is defined by their different social experiences such as making friends, having social interactions with peers, family, and friends, or having social activities. All these social experiences require people to understand and predict other individuals' social behaviors, which calls on our social cognition abilities. Social cognition such as Theory of Mind (ToM) allows people to attribute mental states, namely beliefs, emotions, and desires to others, to understand them and distinguish them from our own (Premack & Woodruff, 1978). Altogether, ToM refers to the ability to understand that mental states are a subjective representation of reality. ToM was first studied in a developmental context, to understand how this social construct was developed in children, and more specifically in children with autism spectrum disorder (ASD) (e.g., Baron-Cohen et al, 1985). Researchers then extended their studies to a more general clinical population suffering from, for example, schizophrenia (e.g., Sarfati & Hardy-Baylé, 1999) or traumatic brain injury (e.g., McDonald & Flagan, 2004). In the last decades, research on ToM has expanded its developmental scope to include healthy older adults (Happé et al., 1998). Although studies in this area have produced inconsistent findings with some articles reporting an age-related decline (e.g., Jarvis & Miller, 2017) and others showing no difference between the young and elderly population (e.g., Hamilton & Krendl, 2023), the reason behind this disparity is still unclear. Henry and colleagues (2013) made a first attempt to explain the possible differences in decline by the conceptual differences found in ToM.

Indeed, the first studies shared a unique definition of ToM, while most recent research has adopted a wider perspective. ToM has been investigated under various other terms such as "mentalizing", "mindreading", "cognitive empathy", "perspective taking" (Quesque & Rossetti, 2020). ToM is now an umbrella term, expressing the comprehension of other individuals' mental states. These changes are reflected in the evaluation of ToM. The first

studies on ToM assessed its cognitive aspect, while a more emotional aspect of ToM started to be investigated later on (Achim et al., 2013). Besides, the literature formulated that cognitive and affective ToM did not rely on the same neural mechanisms (Abu-Akel & Shamay-Tsoori, 2011). Apart from this, ToM is studied under different modalities. The stimuli can either be verbal or visual, with the latter being further divided into visual static and visual dynamic, or a mix of verbal and visual. Authors like Quesque and Rossetti (2020) have even tried to answer the question "What is theory of mind?". This question will not be the target of our meta-analysis, but we will use the different possible constructs to better understand the concept, the tasks, and the mechanisms of ToM in aging.

Traditionally, research on ToM has been conducted using offline static tasks in which participants had to infer others' mental states from static narratives or static social stimuli (Gallotti et al., 2017). This approach, known as a third-person approach, has some important limitations as it does not portray the whole complexity of social interactions. In fact, a third-person approach, also called a theory-theory perspective, is an observational stance of a social interaction between two individuals in which the observer is asked to theorize his knowledge on social norms to understand the mental states of one of the witnessed interactors (Moore & Barresi, 2017). Social interactions come in many forms. They can be verbal or visual, affective or cognitive, but above all they take place in a dynamic interplay between several individuals. Thus, all perspectives are important in a social interaction. We can be observers and actors of a social encounter, or both at the same time. More recently, new naturalistic paradigms arose in which participants take part in social interactions, rather than simply observe them (Fujiwara & Daibo, 2021). This approach, known as a second-person approach, relies on a shared emotional engagement, which means there is a sense of involvement and interaction with the other (Moore & Barresi, 2017). It is characterized by self-directedness, contingency,

reciprocity, affective engagement, and shared intentional relations. Studies are trying to come back to a more social and ecologically valid approach.

As a matter of fact, research has sometimes lost sight of the social environment that surrounds social interactions. Even if the lab experiments brought considerable insight on the development and the dysfunctions in social cognition, it is important to go back to more realistic settings and to reinstate the shared interaction of social encounters. This issue has been called the "real-world or lab" dilemma by Holleman and colleagues (2020). Researchers are trying to return to more ecologically valid tasks, especially in social cognition. A major issue posed by Holleman et al. (2020) is that no consensus exists for the term ecological validity. There are as many definitions as there are articles. Achim et al. (2013) tried to provide a definition and some clear guidelines on how to characterize the ecological validity of a task. In this study, we will consider the fundamental criteria they put forward: the task must be (a) dynamic and (b) infer mental states to real agents, along with (c) the multimodal criteria of Hermans et al. (2019). A task is seen as dynamic when you accumulate information on the characters all along the task, as opposed to capturing a single snapshot. In the second criteria, by real agents we mean either real or virtual humans (realistic avatars or animated characters). Additionally, the multimodal criterion argues that having multiple sources of information rather than one is closer to a real-life setting. The ecological validity of a task can be of importance in aging. Other research domains in aging have shown that older adults can benefit from their experience to counter a decline (Phillips et al., 2006).

Looking at all these different ways of assessing ToM and conceptual approaches, we asked ourselves how these differences in domain, modality, perspective of the respondent, ecological validity and overall task types affect possible age declines in ToM. Could they be responsible for the inconsistencies in the aging literature? As stated above, even if the previous meta-analysis of Henry and colleagues (2013) found no effect of domain and modality on the

tasks, a few more changes have been made in the last decades and plenty of new studies have been published.

Therefore, to address the aforementioned gaps in the literature, we intend to summarize all findings of age-related differences in ToM and include the new developments in the field. Our main aim is to investigate the age-related differences in Theory of Mind (ToM). Our meta-analysis will help to: a) estimate the breadth and magnitude of any ToM difficulties in late adulthood, b) examine whether any observed difficulties are greater than deficits seen on matched control tasks which will address the specificity of any age-related difficulties identified and c) finally test potential moderators' effect of domain (cognitive, affective, mixed), task modality (verbal, visual-static (V-S), visual-dynamic (V-D), verbal and visual-static, verbal and visual-dynamic), task type, ecological validity (dynamic, real agent, multimodal), and perspective of the respondent (first-, second-, and third- person approach).

3. METHOD

3.1. Literature search

A systematic search of the literature was undertaken to identify studies that investigated age-related differences in ToM between young and older adults. For this reason, Pubmed and Scopus databases were searched using both structured vocabulary and free-text combining key-words related with ToM[(theory of mind) or (affective theory of mind) or (cognitive theory of mind) or (social attention) or (mental states) or (mental state attribution) or (mental state understanding) or (social cognition) or (social cognitive skills) or (cognitive empathy) or (empathy) or (mentalizing) or (mentalising) or (perspective taking) or (false belief understanding) or (interpreting mental states)] and age [(community-dwelling older adults) or (healthy ag(e)ing) or (normal ag(e)ing) or (healthy older adults) or (ag(e)ing) or (age-related decline) or (old age) or (age differences)] and tasks [(Faux pas) or (false belief) or (first order false belief) or (second order false belief) or (strange stories) or (Movie for the Assessment of

Social Cognition) or (MASC) or (empathic accuracy) or (director task) or (perspective taking task) or (animation task) or (triangle task) or (Frith-Happé animation task) or (The Awareness of Social Inference Task) or (TASIT) or (EmpaToM) or (reading the mind in the eyes) or (RMET) or (the Cambridge Mindreading Face-Voice Battery)]. The screening of the databases was completed in June 2023.

Furthermore, we went through the list of studies included in the latest meta-analysis on the subject from Henry and colleagues (2013) and added the articles missing from the database search. Our inclusion criteria slightly differed from Henry et al. (2013). Therefore, some of the articles included in their analysis were excluded from ours and vice versa.

3.2. Inclusion criteria

Studies were included if they conformed to the following criteria: (1) cross-sectional study design comparing young to cognitively healthy older adults, (2) assessing behavioral ToM tasks, (3) data convertible to effect sizes explicitly reported, and (4) published in English, French, Italian or Dutch.

Thus, the studies' participant pole had to include a younger group, 90% of whom were aged between 18 and 35 years old, and an older group at 90% composed of 65 years old and over. The older adults' sample could only consist of community-dwelling healthy older adults, which implies that the individuals of the group presented no signs of depression, neurological issues (e.g., Parkinson, dementia, …), nor were they living in a dependent facility (i.e., nursing homes). Studies with clinical populations for both younger and older adults were excluded as well. Additionally, our focus was on ToM performance. Therefore, self-report tasks were excluded, along with tasks judging emotion recognition (e.g., Facial emotions recognition test in Gourlay et al., 2021), or humor (e.g., Uekermann et al., 2006), or social judgment (social judgment task, Gourlay et al., 2021; interpersonal and intrapersonal aspects of the EsCoT,

Baksh et al., 2018 and Baksh et al., 2020), or the advice-taking task (Reiter et al., 2021). Pilot studies were not included.

3.3. Data extracted

The data were extracted from the articles' texts, tables, figures, and supplementary materials. The outcomes of interest were the number of participants, as well as the mean and standard deviations (SD) or standard error (SE) of the accuracy, reaction times, or correctness of the ToM and matching control tasks. In addition, we retrieved demographic data, such as the mean and SD or SE of age, the number of participants, the number of women in each group, along with data concerning the type, the domain, the ecological validity, the modality, and perspective of the respondent of the ToM and matching control tasks. The SEs were computed into SDs.

The first author extracted all the data and, where necessary, contacted the corresponding author of an article to request additional information or data. The second author took another look at the collected data to double check the possible missing information and determine if the task would be included. A consensus about discrepancies was resolved by discussion.

For studies with more than two age groups, only the data from interest groups were extracted. On the other hand, when the groups of interest were divided into multiple groups, weighted means and SDs of the accuracy/correctness/reaction time of the ToM and control tasks were calculated, along with a weighted mean of their age.

For each research paper, the tasks were considered individually and by their domain. Consequently, if the score of a task was divided into cognitive, affective and or mixed domains, all the parts of the task were considered for inclusion. If, for a task, one of the groups or both reached a ceiling effect (SD or SE =0), the task was excluded (e.g., eye tasks Castelli et al., 2010). The control tasks were considered when they were matching the ToM tasks in terms of perspective of the respondent, domain, ecological validity, modality, language used, and

decision-making. If the ToM and control tasks were measured under multiple forms such as accuracy, correctness score, and reaction time, the accuracy or correctness were preferred.

3.4. Types of ToM tasks

We included five of the six basic types of ToM tasks identified by Henry et al. (2013) (Eyes, False belief (FB) video, Faux pas (FP), Stories, and Videos), but we further divided the FB other type into FB cartoon and FB story. We also added two new task types (perspective and virtual reality). A summary of the main characteristics of these task types can be found in Table 1. In the same line as Henry et al. (2013), this table includes the domain of the task type, which can be affective ToM, cognitive ToM or a mix of both, and the modality of the target stimuli. The modality could either be verbal or visual or a mix of both. The visual modality was further divided into visual-static (V-S) and visual-dynamic (V-D). Moreover, the table also includes the ecological validity criteria and the perspective of the respondent. As mentioned previously, the ecological validity criteria were threefold, A) dynamic, B) real agent, and C) multimodal. The respondent (= participant) can be asked to take a first-person, second-person or third-person perspective.

Table 1 : ToM task types and their description

Task type	Required characteristics	Domain	Modality	Example of a task
Eyes	Infer mental states through the eyes of a character (photos or videos). As a matched control condition participants are asked to determine some physical characteristics (age, gender) through the eyes of a character.	Mainly affective	V-S or V-D	*Reading the mind in the eyes* (RMET; Baron-Cohen et al., 2001), for which participants are presented with black and white pictures of the eye region and choose, between four options, which word best describes the feelings or thoughts of the person in that picture.
FB cartoon	Understand a character's false belief through a scenario depicted in 4 illustrated cartoons. As a matched control a cartoon is presented with no false belief scenario, or a question on reality is asked.	Cognitive	V-S	*Theory of Mind Picture Story* (TMPS; Brüne, 2003) consists of six cartoon stories. Two depict reciprocity, two depict deception and two depict a mix of reciprocity and deception. Four illustrated cartoons are presented to the participant in a random order. The participant is asked to order the illustrations to create a coherent story. Once the cards are in the right order, the participants are asked several questions regarding 1st, 2nd order true and false beliefs and 3rd order false beliefs, along with questions on reciprocity, deception, and cheating as well as reality questions.
FB stories	Understand a character's false beliefs through a written story.	Cognitive	Verbal	*Sandbox task* (Bernstein et al., 2011) is a paper and pencil false belief task, where the participant is presented with 5 change-of-location stories.

	For the control task, questions on true belief, reality and memory are asked.			For each story the sequence of events goes as follows: the main character places an object in a location, then a second character changes the location of the object either in presence (true belief) or absence (false belief) of the main character. The participant is then asked where the main character will look for the object.
FB video	Understand character's beliefs through a video.	Cognitive	V-D or verbal and V-D	Very similar to the previous FB task types only that it is assessed through a video.
FP	Detecting faux pas also called social gaffes through stories (most of the time) that can be accompanied by illustrations or pictures, or through videos.	Can be either cognitive, affective or a mix of both	Verbal Verbal and V-S Verbal and V-D	A faux pas task consists generally of various stories describing a situation in which a character commits a faux pas (ToM) or not (control). The participant is asked "if someone said something they shouldn't have said?". In case of a faux pas, they are also asked "Who said something they shouldn't have?". Additionally, the participant can be asked a false belief question and an affective question.
Perspective	Taking your own perspective or the perspective of a character.	Cognitive	V-S or V-D	*Director task* (Dumontheil et al., 2010) is a computer-based task where a character, the director, gives the participant instructions to move objects. Eight objects are placed in a sixteen squared grid, from which the content of some of the grids are occluded from the director's perspective. The director asks the participant to move objects left, right,

				down, or up. In the experimental condition, the target has a competitor object (distractor) that is not seen by the director. In the control condition the objects closed from the director's perspective are irrelevant.
Stories	Appropriately understand a character's mental states by means of a written story.	Mix of both cognitive and affective	Verbal	*Happé's Strange Stories* (HSS; Happé et al., 1994) consists of eight stories in which a subject infers mental states of a character in situation of a faux pas, white lies, persuasion, and double bluffs, along with eight control stories requiring the participants to reason about a physical event.
Video	Infer mental states to characters from a video clip.	Can be either affective, either cognitive or a mix of both	V-D or verbal and V-D	*Sullivan and Ruffman* (S&R) *ToM videos* (Sullivan & Ruffman, 2004) contains 26 (some versions 24 or 16) 2 to 7 seconds colored silent clips in which participants judge the character's feelings and thoughts. The clip is surrounded by two or four mental state options from which to choose. The control videos use the same stimuli, but the participants judge physical characteristics of the character. They are provided with age and gender options.
Virtual reality	Infer mental states while being immersed in a social situation as an avatar of a game in a 1st person perspective.	Mix	Verbal and V-D	The *REALSoCog* (Msika et al., 2022) is a non-immersive VR task, where the participants are asked to follow a defined path and judge 27 situations encountered on the way. 16 situations

	out of the 27 are experimental and include a transgression of social norms.

4. RESULTS

4.1. Statistical analysis

The Cohen's d effect sizes were generated by Rstudio (Posit team, 2023) with the package compute.es (Del Re, 2013). A multivariate meta-analysis with random effect models was computed using the R-package metafor (Viechtbauer, 2010), with the ToM tasks including both ToM and control conditions as dependent variables, on the absolute effect sizes. Additionally, we performed a meta-regression to examine whether any observed difficulties were greater than deficits seen on matched control tasks. In other words, the meta-regression serves to verify if there was an effect of ToM on the tasks. The control tasks were then excluded from the analysis to estimate the breadth and magnitude of any ToM difficulties in late adulthood by performing a second multivariate meta-analysis, for all ToM tasks excluding the control conditions, on the absolute effect sizes. We ran eight more distinct meta-regressions on the ToM tasks excluding the control conditions to assess the possible effects of domain (i.e., affective, cognitive, mixed), modality (i.e., verbal, visual-static, visual-domain, verbal and visual-static, verbal and visual-dynamic), task type (i.e., eyes, FB cartoon, FB stories, FB videos, FP, perspective, stories, and video), ecological validity (criteria A, B, C and total score), and perspective of the respondent (first-, second- and third-person) on the observed age effect. All the analyses were conducted under the restricted maximum-likelihood estimator method.

To assess the within studies heterogeneity, we conducted Cochrane's Q tests. A significant heterogeneity implies a high degree of variability of the underlying parameter, namely the ToM tasks.

To test publication bias we estimated a multilevel meta-regression with standard errors as a moderator. A significant positive relationship between the effect size and the moderator implicates that there is a publication bias.

4.2. Included articles

A total of 1026 potentially relevant articles were identified via databases and 2 additional articles were added by examining the list of included articles in the meta-analysis of Henry and colleagues (2013). 148 duplicates and 12 articles written in languages other than English, Dutch, French and Italian were removed. After screening the titles and abstract, 184 full articles were reviewed for eligibility. Finally, 64 research papers matched our inclusion criteria. The screening process can be found in Figure 1.

For each included study, all ToM tasks were evaluated individually in our data set. Overall, we obtained 110 ToM tasks, named experiment in Table 2 providing the characteristics of each included study. The table is ordered by type of task and includes the measure, the domain, the three ecological validity criteria, the modality, the perspective of the respondent and the eventual control task. The domain and modality were obtained from the initial article. The original division of the task in multiple domains in the articles was preserved in our data set under one experiment as can been seen in the table.

In the reference section, the included articles are identified by an asterisk.

Figure 1 : flow diagram of search and screening process

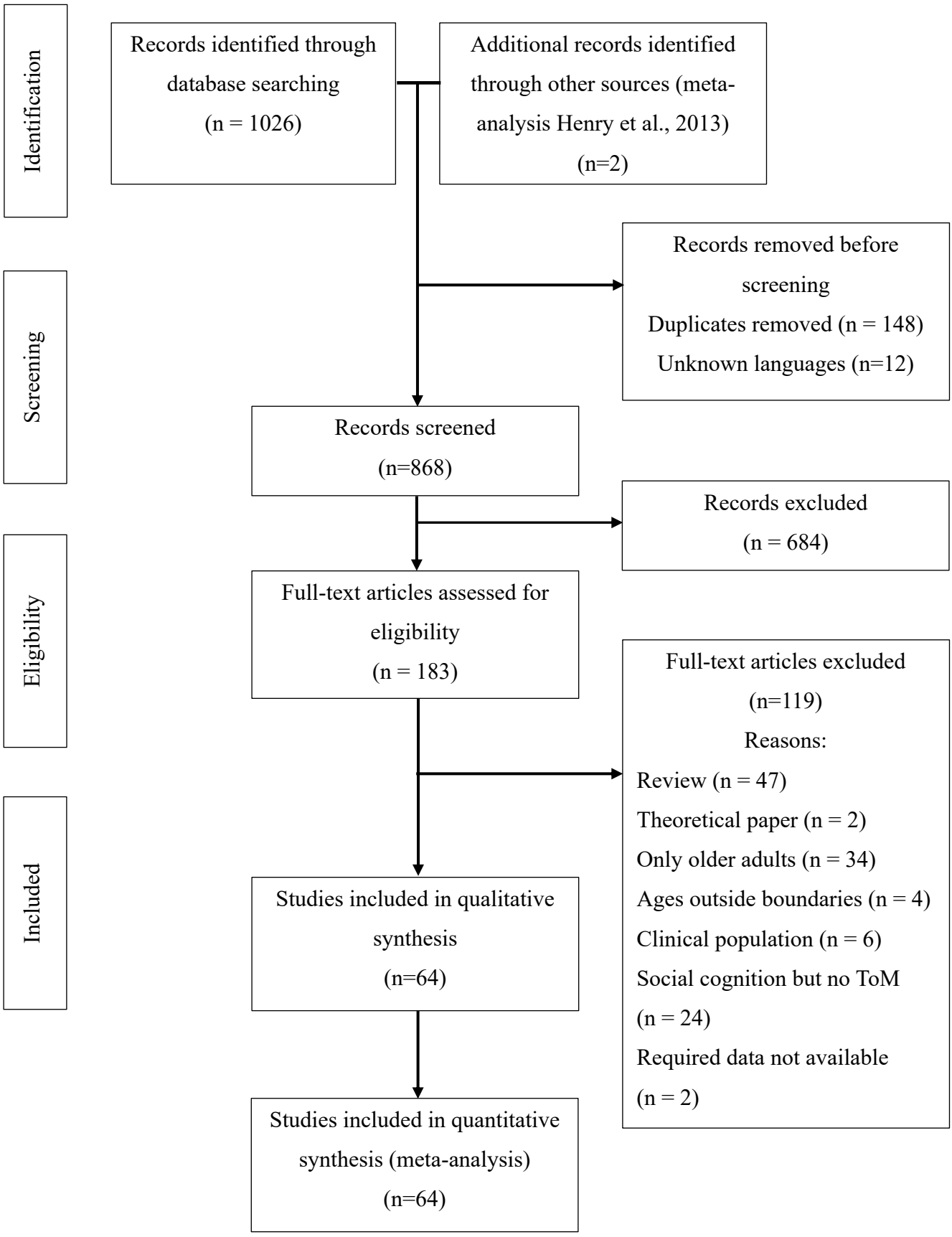


Table 2 : Study characteristics for each included study in the meta-analysis

Task type and	Participants characteristics						ToM task								Effect size	
Article	n		Age (M or range)		n women		Exp	Measure	Dom.	Ecol. validity criteria			Mod.	Persp.	Control	d	Var. d
	Y	O	Y	O	Y	O				A	B	C					
Eyes																	
Bailey & Henry (2008)	36	33	19.5	72.2	25	22	1	RMET	A	0	1	0	V-S	3rd	No	1.06	0.07
Bailey et al. (2008)	80	49	20.8	70.4	57	33	2	RMET	A	0	1	0	V-S	3rd	No	1.4	0.04
Baksh et al. (2018)	30	31	26.2	72.45	15	17	3	RMET	A	0	1	0	V-S	3rd	No	0.16	0.07
							4	JoP	A	0	0	0	V-S	3rd	Physical condition	-0.1	0.07
Braley et al. (2022)	90	87	19.95	71.15	66	60	5	RMET & Yoni test	A	0	1	0	V-S	3rd	No	1.3	0.03
Calso et al. (2019a)	30	50	25.6	76.1	15	35	6	RMET	A	0	1	0	V-S	3rd	No	1.66	0.07
Cassidy et al. (2020)	40	35	21.58	71.66	25	22	7	RMET	A	0	1	0	V-S	3rd	No	0.04	0.05
Duval et al. (2011)	25	25	23.8	70.14	n.a.	n.a.	8	RMET	A	0	1	0	V-S	3rd	No	0.4	0.08
							9	Tom's taste	A	1	0	1	Ve& V-S	3rd	No	0.1	0.08
Fischer et al. (2017)	86	85	19.8	71.4	63	59	10	RMET	A	0	1	0	V-S	3rd	No	1.16	0.03

							11	Yoni Test	C	0	0	0	V-S	3rd	No	0.74	0.03
									A	0	0	0	V-S	3rd	No	0.85	0.03
Grainger et al. (2018)	51	50	20.45	71.67	32	26	12	RMET	A	0	1	0	V-S	3rd	No	0.58	0.04
Grainger et al. (2020)	40	40	19	70.73	20	20	13	RMET	A	0	1	0	V-S	3rd	No	-0.06	0.05
Haj et al. (2016)	40	36	23.13	69.53	22	20	14	RMET	A	0	1	0	V-S	3rd	No	0.88	0.06
Hamilton & Krendl (2023)	136	153	19	74	86	101	15	RMET	C	0	1	0	V-S	3rd	No	0	0.01
Kong et al. (2022)	47	40	19.62	67.2	37	29	16	RMET	A	0	1	0	V-S	3rd	No	0.65	0.05
Kynast et al. (2021)	281	327	20-39	60-79	138	180	17	RMET	A	0	1	0	V-S	3rd	No	0.83	0.01
Li et al. (2013)	28	52	20.46	75.01	15	23	18	RMET	A	0	1	0	V-S	3rd	Physical condition	0.1	0.06
Pardini & Nichelli (2009)	30	30	20-25	70-75	15	17	19	RMET	A	0	1	0	V-S	3rd	No	2.06	0.1
Phillips et al. (2002)	30	30	29.9	69.2	19	15	20	RMET	A	0	1	0	V-S	3rd	No	0.58	0.07
Raimo et al. (2022)	50	88	28.84	68.47	25	43	21	RMET	A	0	1	0	V-S	3rd	No	0.75	0.03
Rosi et al. (2019)	48	48	23.29	70.19	18	10	22	RMET	A	0	1	0	V-S	3rd	No	0.85	0.05
Slessor et al. (2007)	40	40	20.08	66.95	28	25	23	RMET	A	0	1	0	V-S	3rd	Physical condition	0.52	0.05

FB cartoon																	
Calso et al. (2019a)	30	50	25.6	76.1	15	35	24	FB cartoon	C	1	0	1	Ve & V-S	3rd	No	0.85	0.06
							25	MPS-TOMQ	C	1	0	0	V-S	3rd	No	2.21	0.08
Calso et al. (2019b)	35	65	25.43	75.31	18	49	26	MPS-TOMQ	C	1	0	0	V-S	3rd	No	1.28	0.05
Duval et al. (2011)	25	25	23.8	70.14	n.a.	n.a.	27	AIT	C	1	0	0	V-S	3rd	Comprehension	0.87	0.09
							28	FB cartoon	C	1	0	1	Ve & V-S	3rd	Comprehension	0.99	0.09
Haj et al. (2016)	40	36	23.13	69.53	22	20	29	FB cartoon	C	1	0	1	Ve & V-S	3rd	No	0.84	0.06
Keightley et al. (2006)	30	30	25.7	72.5	15	15	30	ToM cartoon	C	1	0	0	V-S	3rd	Comprehension	1.12	0.08
Raimo et al. (2022)	50	88	28.84	68.47	25	43	31	TMPS	C	1	0	0	V-S	3rd	No	0.65	0.03
FB story																	
Bernstein et al. (2011)	38	37	19.22	67.6	28	28	32	Sandbox real objects	C	1	0	1	Ve & V-D	3rd	Memory	0.78	0.06
Castelli et al. (2010)	12	12	25.2	65.2	10	8	33	FB	C	1	0	0	Ve	3rd	Memory & comprehension (ceiling effect)	1.13	0.19
German & Hehman (2006)	27	20	19.51	78.22	18	19	34	FB	C	1	0	0	Ve	3rd	No ToM stories	0.43	0.09
							35	FB	C	1	0	0	Ve	3rd	No	1.23	0.1
Grainger et al. (2018)	51	50	20.45	71.67	32	26	36	FB	C	1	0	0	Ve	3rd	No	-0.01	0.04

Li et al. (2013)	28	52	20.46	75.01	15	23	37	FB	C	1	0	0	Ve	3rd	Comprehension	0.26	0.06
Moran et al. (2012)	31	17	23	71.8	19	8	38	FB	C	1	1	1	Ve & V-S	3rd	No	0.88	0.1
Phillips et al. (2011)	52	36	25.81	73.67	27	21	39	FB	C	1	0	0	Ve	3rd	Comprehension	0.76	0.05
Rahman et al. (2021)	50	50	20.2	67.9	29	38	40	FB	C	1	0	0	Ve	3rd	No	0.13	0.04
Saryazdi & Chambers (2020)	32	32	20.34	71.5	n.a.	n.a.	41	Sandbox	C	1	0	0	Ve	3rd	Memory	0.12	0.06
FB video																	
Bailey & Henry (2008)	36	33	19.5	72.2	25	22	42	FB video	C	1	1	0	V-D	3rd	No	3.57	0.15
Cho & Cohen (2019)	49	49	20.37	69.37	34	37	43	FB video	C	1	1	0	V-D	3rd	No	1.16	0.05
Phillips et al. (2011)	52	36	25.81	73.67	27	21	44	FB video	C	1	1	0	V-D	3rd	Comprehension	0.87	0.05
Yong et al. (2022) population 1	72	68	21.44	71.24	60	46	45	FB video	C	1	1	0	V-D	3rd	No	0.19	0.03
Yong et al. (2022) population 2	97	45	20.82	70.77	n.a.	n.a.	46	FB video	C	1	1	0	V-D	3rd	No	0.34	0.03
Faux pas																	
Bottiroli et al. (2016)	20	42	22.75	65.18	11	27	47	FP	M	1	0	0	Ve	3rd	No FP stories	0.43	0.08
									C	1	0	0	Ve	3rd	No FP stories	1.33	0.09
									A	1	0	0	Ve	3rd	No FP stories	0.2	0.07

Ceccato et al. (2020)	26	25	21.5	75.16	n.a.	n.a.	48	FP	M	1	0	0	Ve	3rd	No	0.73	0.08
Giovag0li (2019)	36	34	26-36	66-81	15	23	49	FP	M	1	0	0	Ve	3rd	Comprehension	0.19	0.06
Hamilton & Krendl (2023)	136	153	19	74	86	101	50	FP	A	1	1	1	Ve & V-D	3rd	Comprehension	0.38	0.01
Li et al. (2013)	28	52	20.46	75.01	15	23	51	FP	M	1	0	0	Ve	3rd	No FP stories	0.12	0.06
Wang & Su (2006)	30	30	21.6	68.93	4	4	52	FP	M	1	0	0	Ve	3rd	No	0.58	0.07
Yong et al. (2022) 1	72	68	21.44	71.24	60	46	53	FP	M	1	0	1	Ve & V-S	3rd	No	0.22	0.03
Yong et al. (2022) 2	97	45	20.82	70.77	65	36	54	FP	M	1	0	1	Ve & V-S	3rd	No	0.56	0.03
Zhang et al. (2013)	61	59	20.67	67.89	29	30	55	FP	C	1	0	0	Ve	3rd	No	0.84	0.04
Zhang et al. (2017)	26	30	22.92	66.17	13	12	56	FP	M	1	0	0	Ve	3rd	No	0.64	0.08
Perspective																	
Baksh et al. (2020)	30	31	22.57	72.3	18	15	57	VPT	C	0	0	0	V-S	1st & 3rd	No	0.66	0.07
Bradford et al. (2023)	86	88	29.5	71.25	62	57	58	Director	C	0	0	1	Ve & V-S	2nd	No distractor	0.53	0.02
Saryazdi & Chambers (2020)	32	32	20.34	71.5	n.a.	n.a.	59	Real - time Director	C	0	0	1	Ve & V-S	2nd	No distractor	0.12	0.06
Stories																	
Braley et al. (2022)	90	87	19.95	71.15	66	60	60	HSS & Yoni	C	1	1	1	Ve & V-S	3rd	No	1.23	0.03

Castelli et al. (2010)	12	12	25.2	65.2	10	8	61	HSS	M	1	0	0	Ve	3rd	Physical stories	1.5	0.21
Cavallini et al. (2013)	30	56	23.63	69.17	n.a.	n.a.	62	HSS	M	1	0	0	Ve	3rd	Physical stories	2.85	0.1
Fischer et al. (2017)	86	85	19.8	71.4	63	59	63	HSS	C	1	0	0	Ve	3rd	No	1.09	0.03
Franco & Smith (2013)	83	89	19.1	69.4	32	53	64	HSS	M	1	0	0	Ve	3rd	Physical stories	0.67	0.02
Gourlay et al. (2021)	41	40	26.68	68.3	21	23	65	HSS	M	1	0	0	Ve	3rd	No	0.17	0.05
Gourlay et al. (2022)	40	40	26.43	68.3	20	23	66	HSS	M	1	0	0	Ve	3rd	No	1.42	0.06
Grainger et al. (2018)	51	50	20.45	71.67	32	26	67	ToM stories	M	1	0	0	Ve	3rd	No	0.03	0.04
Grainger et al. (2020)	40	40	19	70.73	20	20	68	HSS	M	1	0	0	Ve	3rd	Physical stories	0.1	0.05
Happé et al. (1998)	69	19	21.75	73	34	10	69	HSS	M	1	0	0	Ve	3rd	Physical stories	-1.13	0.07
Jarvis & Miller (2017)	30	31	20.36	78.73	18	24	70	ToM stories	A	1	0	0	Ve	3rd	No ToM stories	3.1	0.14
									M	1	0	0	Ve	3rd	No Tom stories	3.39	0.16
									C	1	0	0	Ve	3rd	No Tom stories	2.2	0.11
Keightley et al. (2006)	30	30	25.7	72.5	15	15	71	ToM stories	M	1	0	0	Ve	3rd	Inferences	0.39	0.07
Lecce et al. (2018)	30	70	21.97	73.67	21	43	72	HSS	M	1	0	0	Ve	3rd	Physical stories	0.76	0.05
Maylor et al. (2002) exp. 1	25	50	19	74.1	10	35	73	(mostly based on) HSS	M	1	0	0	Ve	3rd	Physical stories	0.99	0.07

Maylor et al. (2002) exp. 2	30	30	21.2	80.6	16	17	74	(mostly based on) HSS	M	1	0	0	Ve	3rd	Physical stories	0.96	0.07
Mckin0n & Moscovitch (2007) exp. 1	12	12	20.16	78.18	n.a.	n.a.	75	ToM stories	M	1	0	0	Ve	3rd	No	1.42	0.21
Raimo et al. (2022)	50	88	28.84	68.47	25	43	76	ATT	M	1	0	0	Ve	3rd	No	0.6	0.03
Rakoczy et al. (2012)	27	20	22.67	73.3	14	9	77	HSS	M	1	0	0	Ve	3rd	Physical stories	0.81	0.09
Rakoczy et al. (2017)	40	40	24.35	68.43	25	23	78	HSS	M	1	0	0	Ve	3rd	Physical stories	0.62	0.05
							79	Wis-Tom	M	1	0	0	Ve	3rd	No	0.22	0.05
Slessor et al. (2007)	40	40	20.08	66.95	28	25	80	ToM stories	M	1	0	0	Ve	3rd	Inferences	0.21	0.05
Stewart et al. (2019)	31	26	24.94	73.04	28	18	81	HSS	M	1	0	0	Ve	3rd	No	0.04	0.07
Sullivan & Ruffman (2004)	24	24	30	73	11	16	82	HSS	M	1	0	0	Ve	3rd	Physical stories	1.38	0.1
Wang & Su (2006)	30	30	21.6	68.93	4	4	83	ToM stories	M	1	0	0	Ve	3rd	Inferences	-0.38	0.07
Wang & Su (2013)	32	74	26.53	73.34	16	37	84	ToM stories	C	1	0	0	Ve	3rd	Physical stories	1.68	0.06
									A	1	0	0	Ve	3rd	Physical stories	-0.12	0.04
									M	1	0	0	Ve	3rd	Physical sotires		
Video																1.11	0.05
Baksh et al. (2018)	30	31	26.2	72.45	15	17	85	EsCoT	C	1	1	0	V-D	3rd	No	0.61	0.07

									A	1	1	0	V-D	3rd	No	0.24	0.07
							86	RMF	A	1	1	1	Ve & V-D	3rd	No	-0.09	0.07
Baksh et al. (2020)	30	31	22.57	72.29	18	15	87	ESCoT	C	1	1	0	V-D	1st & 3rd	No	0.98	0.07
									A	1	1	0	V-D	1st & 3rd	No	0.58	0.07
Burdon et al. (2016)	21	21	30.6	68.9	n.a.	n.a.	88	TASIT 2	M	1	1	1	Ve & V-D	3rd	No	1.73	0.13
							89	TASIT 3	M	1	1	1	Ve & V-D	3rd	No	1.35	0.12
Ceccato et al. (2020)	26	25	21.5	75.16	n.a.	n.a.	90	Animation task	C	1	0	0	V-D	3rd	No	1.27	0.09
Gigi & Papirovitz (2022)	51	53	25.3	69.97	32	33	91	Animation task	C	1	0	0	V-S	3rd	Random clips	0.34	0.04
Grainger et al. (2019)	48	50	20.67	75.38	33	33	92	TASIT 2	M	1	1	1	Ve & V-D	3rd	No	0.18	0.04
							93	TASIT 3	M	1	1	1	Ve & V-D	3rd	No	0.34	0.04
Grainger et al. (2020)	40	40	19	70.73	20	20	94	VAMA	A	1	1	1	Ve & V-D	3rd	No	0.55	0.05
									C	1	1	1	Verbal & V-D	3rd	No	0.49	0.05
Grainger et al. (2023)	124	134	21.69	78.03	79	90	95	TASIT-S 3	M	1	1	1	Ve & V-D	3rd	No	1.32	0.02

Hamilton & Krendl (2023)	136	153	19	74	86	101	96	ToM video	C	1	1	1	Ve & V-D	3rd	Comprehension	0.35	0.01
Johansson Nolaker et al. (2018)	20	19	21	70	17	10	97	SSFT	M	1	1	1	Ve & V-D	3rd	No ToM videos	0.82	0.11
Krendl et al. (2023)	111	120	19.1	74.68	61	64	98	ToM video	C	1	1	1	Ve & V-D	3rd	Comprehension	-0.25	0.02
Lecce et al. (2018)	30	70	21.97	73.67	21	43	99	MASC	M	1	1	1	Ve & V-D	3rd	Memory & comprehension	1.93	0.07
Mahy et al. (2013)	30	30	22.53	72.13	10	22	100	CAM (face)	A	1	1	0	V-D	3rd	No	0.52	0.07
McDonald et al. (2017)	214	142	20-39	60-74	n.a.	n.a.	101	TASIT 2	M	1	1	1	Ve & V-D	3rd	No	0.72	0.01
							102	TASIT 3	M	1	1	1	Ve & V-D	3rd	No	0.44	0.01
Rakoczy et al. (2012)	27	20	22.67	73.3	14	9	103	S & R	A	1	1	0	V-D	3rd	No	1.36	0.11
Reiter et al. (2017)	55	52	24.29	72.08	31	30	104	EmpaToM	M	1	1	1	Ve & V-D	1st & 3rd	Factual reasoning	1.33	0.05
Slessor et al. (2007)	40	40	20.08	66.95	28	25	105	S & R	A	1	1	0	V-D	3rd	Physical video	0.71	0.05
Stewart et al. (2019)	31	26	24.94	73.04	28	18	106	Animation task	C	1	0	0	V-D	3rd	No	0.12	0.07
Stietz et al. (2021)	42	44	24	69.5	21	22	107	EmpaToM	M	1	1	1	Ve & V-D	1st & 3rd	Factual reasoning	1.5	0.06

Sullivan & Ruffman (2004)	24	24	30	73	11	16	108	S & R	A	1	1	0	V-D	3rd	No	0.79	0.09
Zhang et al. (2017)	26	30	22.92	66.17	13	12	109	Animation task	C	1	0	0	V-D	3rd	No	0.94	0.08
Virtual reality																	
Msika et al. (2022)	47	45	24.79	72.27	27	30	110	REALSoCog	A	1	1	1	Ve & V-D	1st, 2nd & 3rd	No	0.84	0.05
									C	1	1	1	Ve & V-D	1st, 2nd & 3rd	No	0.11	0.04

Note. When several groups of younger or older adults (ex. Low, high education/performance, old, very old) were present in one article, a mean of their age and performance were calculated.

Exp = experience, which allows to separately consider multiple experiences within the same paper and thus maintain the different scores of domain for the same task present in a paper; Dom = Domain; Ecol. Validity criteria = Ecological validity; Ecological criteria A = dynamic: the task allows for incremental learning about the agent during the task (as in the MASC) rather than presenting a single snapshot (as in the RMET); Ecological criteria B = agent: mental states are attributed to real or virtual (realistic virtual reality avatars or animations) humans rather than to story characters (as in the Strange Stories) or non-humans (as in the animation task); Ecological validity criteria C = multimodal: information in the task are given via more than one source of information (perceptual and visual) rather than via a single source of information (as in the triangle) more than one modality 0 = does not meet the criteria, 1 = meets the criteria; Mod. = modality where Ve = Verbal, V-S = visual-static, and V-D = visual-dynamic; Persp = perspective of the respondent; Effect size: d = Cohen's d and var. d = the variance of the Cohen's d; measure refers to the ToM measure used in the article : RMET = Reading the mind in the eyes (Baron-Cohen et al., 2001), JoP= Judgment of preference task (Girardi et al., 2011) (similar to ToM's taste), Yoni test (Shamay-Tsoory & Aharon-Peretz, 2007) (similar to Tom's taste) , Tom's taste (Snowden et al., 2003), MPS-TOMQ = Mind Picture sequencing – Theory of Mind questionnaire (Calso et al., 2019a), AIT = Atribution of Intention task (Brunet et al., 2000), FB = False belief tasks, Sandbox task (real objects) (Bernstein et al., 2011), TMPS = Theory of Mind Picture Sequencing task (Brüne, 2003), FP = faux pas tasks, VPT = Visual Perspective Taking task (Samson et al., 2010), Director task (Dumontheil et al., 2010), Real-time communicative Director task (Saryazdi et al., 2020), HSS = Happé's Strange Stories task (Happé et al., 1998), ToM stories are based on multiple stories tasks, ATT = Advanced Test of ToM (Prior et al., 2003), WisTom = Wisdom/ToM task (Rakozcy et al., 2017), EsCoT = Edingburgh Social Cognition Test (Baksh et al., 2018), RMF = Reading the Mind in Films (Girardi et al., 2011), CAM =

Cambridge Mindreading Face-Voice Battery (Golan et al., 2006), TASIT = the Awareness of Social Inference Test (McDonald et al., 2004), Animation task: Frith-Happé animations task (Abell, 2000), VAMA = Virtual Assessment of Mentalizing Ability (Grainger et al., 2020), MASC = The Movie for the Assessment of Social Cognition (Dziobek et al., 2006), SSFT = Strange Story Film task (Murray et al., 2017), EmpaTom task (Kanske et al., 2015), S&R = Sullivan and Ruffman (2004) ToM videos, REALSoCog task (Msika et al., 2022).

4.3. Age effect in the ToM tasks

An overall age effect was found on the 110 ToM tasks retrieved (d=0.73 [95% CI = 0.61, 0.84], z=11.93, p<0.001), indicating that older adults had more difficulties in the ToM tasks than younger adults (see Figure 2). On the other hand, the total heterogeneity was significant ($Q_{T(120)}$=861.16, p<0.001), pointing to a variance between the different included ToM tasks.

4.4. Effect of ToM on the age-related differences

From 64 included publications, a total of 110 ToM tasks were retrieved, of which only 41 had a matching control task. The control of the FB task in the study of Castelli and colleagues (2010) had a ceiling effect and was therefore not included in the analysis. We thus conducted a meta-regression with the control conditions as inner factor and the ToM tasks as outer factor. We discovered a significant variability between the experimental and the control conditions ($Q_{M(1)}$=6.67, p = 0.0098) on the age difference between the task. The model *(*b= -0.268) showed that the age differences in the matched control conditions were smaller than the age effects in the experimental condition, which demonstrates an effect of age-related decline in ToM. The heterogeneity test revealed a variability in the ToM effect between the different ToM tasks ($Q_{T(160)}$=1232.12, p <0.001).

4.5. Effect of the moderators on the age-related differences

A distinct meta-regression was computed for each moderator.

A. Task type

From the meta-regression using the task type as covariate, no evidence was found that suggested the type of task (eye, FB cartoon, FB stories, FB video, perspective, stories, videos, or VR) had a moderating effect on the age decline in the experimental condition of the ToM tasks ($Q_{M(9)}$=8.14, p=0.520). Furthermore, the heterogeneity between the ToM tasks remained significant ($Q_{T(111)}$= 804.35, p<0.001).

B. Domain

The meta-regression analysis including the domain showed no moderating effect of domain (cognitive, affective or mixed) on the age-related differences in the experimental conditions of the ToM tasks ($Q_{M(2)}$=0.833, p=0.659). Once again, a significant variability in the ToM tasks persisted ($Q_{T(118)}$= 856,99, p<0.001).

C. Modality

Similarly, the meta-regression with the modality as covariate did not display a moderation of the modality (verbal, visual-static, visual-dynamic, verbal and visual-static, and verbal and visual-dynamic) on the age differences in the experimental condition of the ToM tasks ($Q_{M(4)}$=1.839, p=0.765). Here again, the heterogeneity continued to be significant ($Q_{T(116)}$= 852,63, p<0.001), which confirms the lack of moderation of the modality on the experimental conditions.

D. Ecological validity

For the ecological validity, an ecological score was computed as the sum of the scores of each criterion. It ranges between 0 and 3.

Just as the previous meta-regressions, using the ecological validity score as a covariate did not suggest a moderation of the ecological validity in age-related decrease in the experimental condition of the ToM tasks ($Q_{M(1)}$=0.606, p=0.436). It did not influence the significance of the heterogeneity ($Q_{T(119)}$=860.108, p<0.001), because the variance of the experimental conditions in the ToM tasks remained.

Additionally, three other meta-regressions on the individual criteria were conducted to establish if the individual criteria moderated the effect of age.

The first criterion (dynamicity) had no moderating effect on the age decline ($Q_{M(1)}$=0.218, p=0.641), and the variance between the experimental conditions of the ToM tasks stayed significant ($Q_{T(119)}$=861,161, p<0.001). In the same way, the second criterion (real agent)

did not moderate the effect of age-related differences ($Q_{M(1)}$=0.92, p=0.337), neither the significance of the heterogeneity ($Q_{T(119)}$=861,152, p<0.001). The trend was the same for the last criterion (multimodality): no moderation on the age decline ($Q_{M(1)}$=0.06, p=0.80) and a persistent significant heterogeneity ($Q_{T(119)}$=856,216, p<0.001).

E. Perspective of the respondent

In the last meta-regression, including the perspective of the respondent (first-, second-, third-person) as moderator showed no moderating effects of the aforementioned perspectives on the experimental condition of ToM tasks ($Q_{M(3)}$=2.154, p=0.541). The significant heterogeneity of the experimental conditions held on ($Q_{M(117)}$=842.896, p<0.001).

4.6. Publication bias

To verify the publication bias of our included articles, we conducted a meta-regression analysis including the standard error as moderator. This meta-regression exposed a strong publication bias ($Q_{M(1)}$=32.814, p<0.001; b=4.78 [95%CI=3.14, 6.42], z=5.728, p<0.001), where the included studies with smaller samples reported bigger effect sizes (see Figure 3).

Figure 2 : Age-related decline in experimental conditions of the ToM tasks

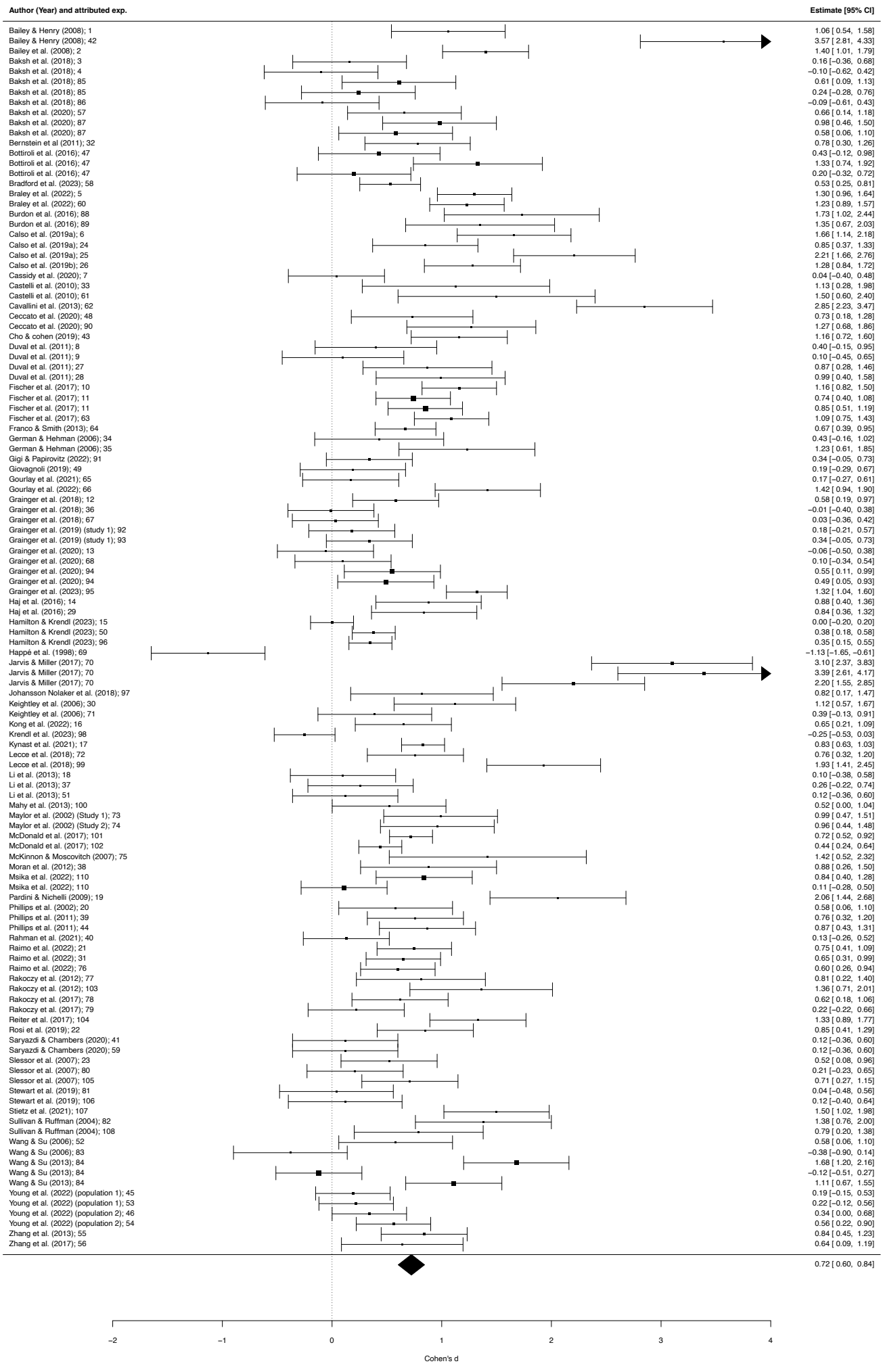
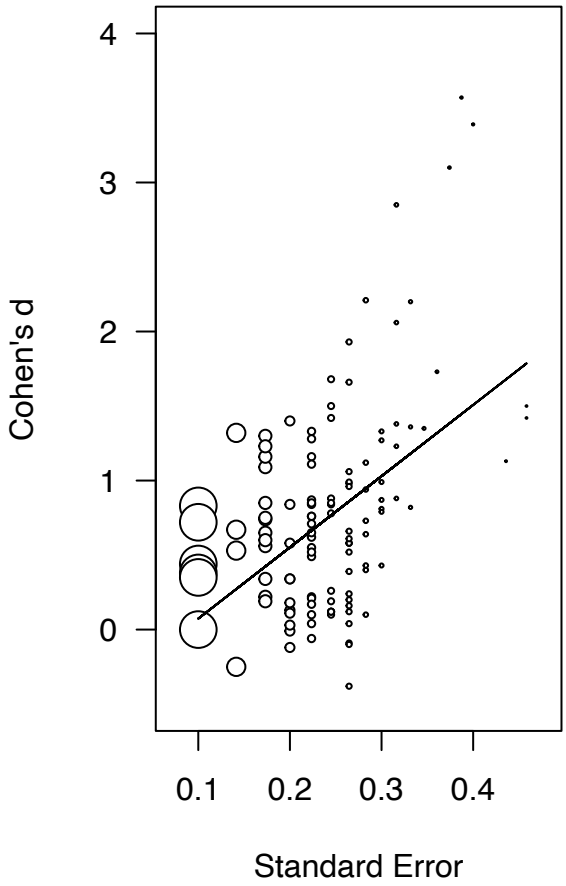


Figure 3 : Representation of publication bias



Note: The area of the point is proportional to the inverse variance.

5. DISCUSSION

Due to a broader interest on the age-related decline in ToM and the possible causes for this decline, the number of articles on ToM performance comparing younger and older adults increased since the last meta-analysis (Henry et al., 2013), maintaining the inconsistencies in results about an existing age-related decline. Furthermore, the field of ToM expanded in terms of definitions, measures, perspective of the respondent, along with a reconsideration of the social aspect and ecological validity of it all. Considering all these new developments and the disparities in the results on the aging literature in ToM, we decided to perform a new meta-analysis. Our aim was to (1) evaluate the possible difficulties in ToM for older adults, (2) investigate if the eventual decrease in the performance on ToM tasks were actually more present in experimental conditions compared to matched controls, and (3) verify if the further

developments in ToM tasks, namely task types, domains, modalities, perspective of the respondent and ecological validity moderated the age-related difficulties in the ToM tasks.

In contrast with the former meta-analysis of Henry and colleagues (2013), we opted for a novel meta-analysis approach, the multivariate meta-analysis. We performed two multivariate meta-analyses, instead of conducting several univariate meta-analyses. A multivariate meta-analysis increases statistical power and provides more reliable results than a simple univariate meta-analysis. More specifically, it allowed us to consider all the moderators in the same meta-analysis in order to combine multiple effect sizes and analyze them through several distinct meta-regressions.

Apart from the analytical change, we also included 64 papers in contrast to the 22 papers found in the former meta-analysis. A substantial number of papers have been published on the subject in the last 10 years. Together with this new interest in the literature on aging and ToM came some important conceptual variations that we merged into our new task categories and other possible moderators of the age effect found in the ToM tasks.

Our results reported a clear age-related decrease in ToM performance for older adults compared to younger samples, which is consistent with the findings of Henry et al. (2013) despite the difference in analytical procedure. However, the tasks showed a strong variability in their measure of the age-related decline. This shows that while the different ToM tasks varied in their assessment of age-related gaps in ToM, the age-related differences remained through the diverse implementation of these ToM tasks. Even though ToM tasks seem conceptually and methodologically diverse, they still seem to capture a systematic decline. According to Osterhaus and Bosacki (2022), to find a consistent age-related difference in abilities establishes that the different tasks measure a similar construct.

Consequently, we asked ourselves if this decline was moderated by the multiple components of a ToM task, such as the type of task (i.e., eyes, FB cartoon, FB story, FB video,

FP, perspective, stories and videos), the domain (affective, cognitive, and mixed), the modality (verbal, visual-static, visual-dynamic, verbal and visual-static, or verbal and visual-dynamic), the ecological validity, and the perspective of the respondent (first-, second-, third-person) and our results showed no moderator effect of any kind. None of the above-mentioned covariates had an influence on the age-related differences in ToM performance, nor on the variance of the measure of this age-related depreciation in ToM.

The lack of change on the variation between the ToM tasks reveals that these different tasks measure different components of ToM. Acknowledging that these disparate tasks were created to measure different aspects of ToM, there should be no surprise here. It is interesting to mention that the activation of different neuronal pathways in cognitive and affective ToM (Abu-Akel & Shamay-Tsoori, 2011) doesn't seem to play a role in the difficulty for older adults in ToM abilities. The same results were displayed for the modality, even if in other fields, like detection of deception (Sun et al., 2020), older adults demonstrated more difficulties in visual modalities compared to others. For ToM performances, the type of modality did not soften or worsen the age-related differences, nor the variability between the tasks. Both outcomes inform us on the fact that the age-related difficulties could be related to the underlying complexity of the very concept of social cognition and not its operationalizations.

Furthermore, it should be noted that two third of the tasks had a low ecological validity score (score of 0 or 1), and that over ninety percent of the tasks had a third-person perspective for the respondent. In addition, only one VR task and 3 perspective taking tasks met the criteria of our meta-analysis out of the 110 tasks that were included. It could thus be difficult to draw any definitive conclusions regarding these possible moderators and assume that the age-related decline persists in interactive tasks with a higher ecological validity.

Less than forty percent of the included tasks assessed a control condition to ensure that the age-related differences were due to ToM. Nevertheless, for the ToM tasks with a matching

control, a clear effect of ToM was determined. As emphasized in the previous meta-analysis (Henry et al., 2013), there is a need for ToM tasks to include more matching control conditions, to be able to analyze the specific effects of ToM more in depth. Another issue is that the meta-analysis highlighted the great variability between the different ToM measures, on which the moderators did not appear to have an effect. Consequently, it would be interesting to test other possible factors of age decay such as cognitive abilities, or sample characteristics.

Despite the different analytical method, i.e., the new studies conducted and the changes in the ToM paradigms, we found the same results as the previous meta-analysis (Henry et al., 2013). It is very interesting to notice that we reach the same conclusions as Henry and colleagues (2013). This suggests that the age-related deterioration is not due to the way the task is operationalized and that the tasks study different components of the same social cognitive concept. Hence, the decay could be caused by something utterly binded to ToM abilities or be linked to more cognitive parameters, which is yet to discover. We also observed that in over a decade, the tasks were not leaning towards more ecological validity or a use of diverse perspectives of the respondent.

Overall, this meta-analysis updates the findings on age-related differences in ToM by taking into consideration the literature on the subject published in the last 10 years as well as reevaluating the different components of the new tasks and visions on ToM. We recommend for future research to opt for more ecological tasks and to vary the perspective of the respondent to have a clearer vision on their effect on the ToM performance. Additionally, we advise a future meta-analysis to consider the characteristics of the sample like level of education (e.g. Li et al., 2013; Yong et al., 2022), vocabulary (Fliss et al., 2016; Lecce et al., 2019), or cognitive dimensions (Charlton et al., 2009; Otsuka et al., 2021; Saltzman et al., 2000; Yildirim et al., 2019), for which an interest on their association to ToM abilities can be found in the literature. Since the reasons of the decline do not seem to be influenced by the different aspects of the

tasks, it could be moderated by the general decline (e.g., cognitive reserve, executive functions) seen in older adults.

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Chapter IV. Study 2 - Spontaneous and self-reported perspective-taking: age- and cultural-related differences in young and older adults from an individualistic or collectivistic culture.

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1. ABSTRACT

Social context can require individuals to take another person's perspective. This ability could be influenced by our culture or our age. In fact, some studies reveal that collectivistic cultures do not distinguish their own perspective from the point of view of the other and therefore tend to take an egocentric perspective (representational theory), while other research states that collectivists will more easily adopt the alter-centric perspective (attentional theory). Moreover, perspective-taking has been established to decline with age. However, no studies have investigated the cultural and age interaction effects. The aim of this study was to investigate the difference in spontaneous perspective tendencies between younger and older adults of collectivistic and individualistic cultures. A sample of 83 younger and 56 older adults of an individualistic culture, as well as 25 younger and 26 older adults of a collectivistic culture completed an online spontaneous perspective-taking task. Older adults, independent of the culture, needed more time to adopt a perspective, especially when they took the other's perspective. In addition, more collectivistic adults adopted a first-person perspective than individualistic adults, supporting the representational hypothesis. Additionally, the study informs us that in a spontaneous setting older and younger adults do not differ in the perspective they adopt, but that older adults' egocentric perspective interferes when they are trying to take another person's perspective. Spontaneous perspective-taking in aging deserves to be further investigated as an eventual basic competence of perspective-taking.

Keywords: Spontaneous perspective-taking, aging, collectivism, cultural differences

2. INTRODUCTION

A primary assumption about Humans is that they are egocentric by nature. Individuals tend to use an egocentric frame of reference in social interactions or situations. On the other hand, it is crucial to take someone else's perspective during social encounters, whether it is merely perceptual, cognitive, or emotional. Importantly, the perceptual aspect alone includes visuospatial and spatial clues, whereas the cognitive and emotional, i.e. affective, aspect would be addressed as Theory of Mind (ToM) or mentalizing (Erle & Topolinski, 2017).

All these aptitudes are central in social interaction to understand a person's referential, not only to attribute and understand people's mental states or differentiate them from our own but also to be able to divide the environment that surrounds us. Individuals tend to use self- or other-oriented spatial reference frames, e.g., in front of me, at your left.

Differing from a long-lasting belief, Carruthers (2015) has put a single mind-reading system forward, posting that perceptual and emotional perspective-taking are part of one system, which has been supported by the findings of Elekes et al. (2016). The model states that the mindreading system can operate spontaneously, automatically, or deliberately relying on the context. The process is automatic when the participant considers the perspective or mental states of a third party even if it is not relevant to the task. This process cannot be inhibited (O'Grady et al. 2020). In opposition to spontaneous processes which are related to implied intentions, such as understanding or predicting social behavior, and appear when required, making them relevant (Elekes et al., 2016). Either process can happen unconsciously and involuntarily and does not involve working memory or executive functions to attribute mental states. On the other hand, deliberate perspective-taking occurs consciously and leans on explicit intentions. Automatic, spontaneous, and deliberate perspective-taking depend on the target of the task.

Furthermore, three forms of task designs can induce visuospatial perspective-taking, i.e., explicit, implicit, and uncued tasks (O'Grady, 2020). During an explicit perspective-taking task, the participant is asked to take her/his point of view (first person) or the other's point of view (third person). On the other hand, only a first-person perspective is requested within an implicit task. The third-person perspective is often referred to throughout the task but is not explicitly relevant to the task (O'Grady, 2020). Finally, the uncued task in which the participant is not inquired to take a perspective and the relevance of perspective-taking is not disclosed.

Additionally, the self and other perspectives can thus vary (Qureshi et al., 2019). To attribute perception, the first step is to analyze if the stimulus is perceived by the other. The second step is to examine how the object is perceived by the other (Elekes et al., 2016). Level-1 perspective-taking informs the mindreading system about which object to attribute mental states to whereas the Level-2 perspective-taking goes a step further by reporting the features of the object, which can change depending on the viewpoint. It could explain some challenges in the base mechanisms in ToM and the differences in social ability, especially in older adults for whom the aptitude to take someone else's perspective has proven to decline (Healey & Grossman, 2016).

The literature on perspective-taking in aging is quite scarce but reveals that older adults have a lower perspective-taking ability (Healey & Grossman, 2016; Martin et al, 2019b; Mattan et al., 2017; Saryazdi et al., 2020). The older population display more difficulties in communicating perspective-taking clues allowing a conversational partner to determine the targeted stimuli (Healey and Grossman, 2016). Healey and Grossman (2016) also demonstrated that this decline is multifactorial, partially due to a decline in cognitive capacities such as working memory as well as a general decline in perspective-taking. A greater egocentric interference and first-person egocentrism are observed in older adults, meaning that they concentrate more on a self-relevant perspective, especially if the other and self-perspective

diverge (Mattan et al, 2017). The literature also demonstrated that older adults manifested a greater switching cost from the self to the other perspective (Martin et al., 2019b; Mattan et al., 2017). Martin and colleagues (2019b) evidenced that these impairments in older adults could be found in both Level-1 and Level-2 perspective-taking tasks. In addition, they found that working memory alone was not sufficient to explain this expansion of egocentric bias and perspective. Saryazdi et al. (2020) indicated that older adults were more inadequate at spontaneously using perspective cues. All the above-mentioned researchers used explicit or implicit perspective-taking tasks, testing for automatic, spontaneous, and deliberate perspective-taking, but there is no mention of uncued tasks in aging. This study aims at looking for spontaneous responses in an uncued perspective-taking task.

The first mention of such a task in the perspective-taking literature was by Tversky and Hard (2009). They wondered if spontaneous perspective-taking could also occur in an uncued Level-2 task. They designed a visuospatial task where a participant had to give a spatial relation between two objects without having any reference frame. This study showed that a quarter of the sample took the other's perspective when there was an actor present in the picture. In a second experiment, Tversy and Hard (2009) revealed that phrasing the demand in terms of movement increased the third-person perspective-taking. The demand-oriented phrasing would focus the participant on the potential action and, thus, create an anticipation of the other person's action, which partially defines perspective-taking according to them. In the case of demand-oriented phrasings, half of their sample took the actor's perspective. These findings were replicated and even enhanced in other studies (Conson et al., 2017; Millett et al., 2020; Quesque et al., 2018). Quesque et al. (2018) and Millett and colleagues (2020) discovered that spontaneous perspective-taking occurred even when the other person cannot act upon or see the stimulus. The mere presence of another person is enough to infer the other's perspective.

Since perspective-taking is embedded in social exchanges, studies have investigated the effect of cultures and their various social dimensions on people's perception. For instance, the cultural differences between individualism and collectivism have engendered two main hypotheses (Wu and Keysar, 2007) on perspective-taking, i.e., the representational and attentional hypothesis. The representational hypothesis states that in a collectivistic society, individuals are interdependent which leads them to not distinguish their perspective from the perspective of the other individuals. Alternatively, the population from an individualistic culture affirms their independence and would be more prone to imagine that another person's perspective differs from their own. Instead, the attentional hypothesis declares that an interdependent individual tends to be less self-centered and to consider the other person's perspective more than their own, contrary to independent people.

The study of Wu and Keysar (2007) endorsed the attentional hypothesis. The collectivistic population of their research had less interference of their own perspective and took the third person's perspective more easily than the sample from the individualistic culture.

In a study of Martin et al. (2019a), with a task in which participants were asked to switch from the self- to the other-perspective and vice versa, the collectivistic participants manifested an interference of the alter-centric perspective when the perspective switched from the other to the self. Apart from this, they were slower at adopting the other-perspective. These results corroborated the representational hypothesis by exhibiting a unification between the self- and other-perspective. Other studies (Bradford et al., 2018; Chopik et al., 2016) did not find any differences in perspective taking between these two cultures. Yet more, Chopik and colleagues (2016) did not find any association between individualism or collectivism and perspective taking, nor any of the other Hofstede social dimensions (namely, power distance, masculinity, uncertainty avoidance and long-term orientation; Hofstede et al., 2010).

Consequently, this study addresses the possible age-related differences between younger and older adults from different cultures in uncued spontaneous perspective-taking. No literature has been found about the interaction of age and cultural differences, like we attempt to investigate in this paper. We wondered which perspective older adults would spontaneously take in an uncued Level-2 visuospatial perspective-taking task. Since older adults have more trouble taking the other's perspective and have a greater egocentric bias, we hypothesize that they will spontaneously tend towards a self-perspective in an uncued task. Due to the conflicting literature on the effect of culture in perspective taking, no particular hypothesis is made. We just hope that this study in a spontaneous uncued setting would favor one of the hypotheses. We imagine that if our results lean towards the representational hypothesis, older adults will be even more impacted due to the egocentric interference. However, if the attentional hypothesis is supported by our results, we expect older adults to not show such a strong tendency to take the alter-centric perspective. Therefore, concerning the interaction effect of age and culture, we make different assumptions for the two cultural hypotheses, namely that the cultural difference between younger and older adults tend to vary across age in two different ways. In case of the representational hypothesis, we expect an increase of egocentric interference in the collectivistic older adults in comparison to the individualistic older adults. However, in case of the attentional hypothesis, we assume that the egocentric bias will decrease for the collectivistic older adults compared to the individualistic older adults.

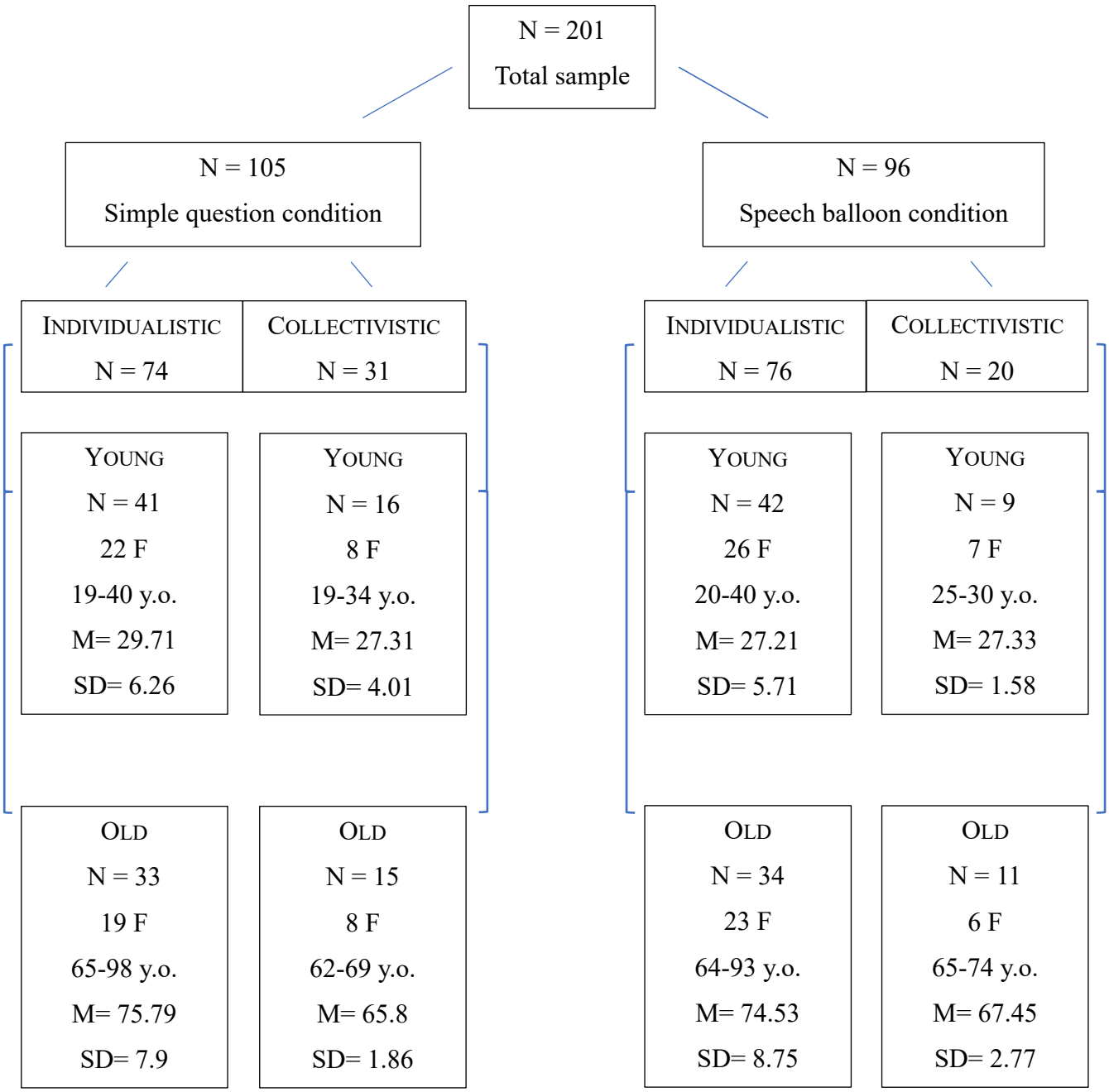
Moreover, the task would also assess the differences in perspective-taking for movement and static task categories. Based on the study of Tversky and Hard (2009), we hypothesize that most younger adults will adopt a third person perspective for the task with the movement phrased demands compared to the static demands. We do not specially expect the same change of perspective in older adults for whom we suspect a difficulty in taking the alter-centric perspective.

3. METHOD

3.1. Participants

A sample of 201 volunteers from Belgium, Italy and Turkey were recruited through word-of-mouth, cultural and recreational centers. They were divided into 2 cultures: individualistic for Belgium and Italy, and collectivistic for Turkey, then subdivided into two conditions and 2 age groups (see Figure 4). The educational level, measured by the highest obtained degree, was significantly different between the two age groups for the collectivistic sample ($F_{(1,49)}$=14.71, p<0.001; M_{young}= 5.36, SD_{young}= 0.7, M_{old}= 4.35, SD_{old}= 1.13), but the education between the young and older adults of the individualistic sample was only close to significance ($F_{(1,148)}$=3.51, p=0.063; M_{young}= 4.98, SD_{young}= 1.05, M_{old}= 4.58, SD_{old}= 1.52). The difference in level of education between the two cultures in the younger age sample ($F_{(1,106)}$=2.83, p=0.089) and the older sample was not significant ($F_{(1,91)}$=1.04, p=0.475). The degrees were scored from 1 = No education, 2 = Elementary, 3 = Middle school, 4 = High shool, 5 = Bachelor Degree, 6 = Master Degree, 7 = Ph.D./Specialization.

Figure 4 : schema of the sample distribution



3.1. Measures

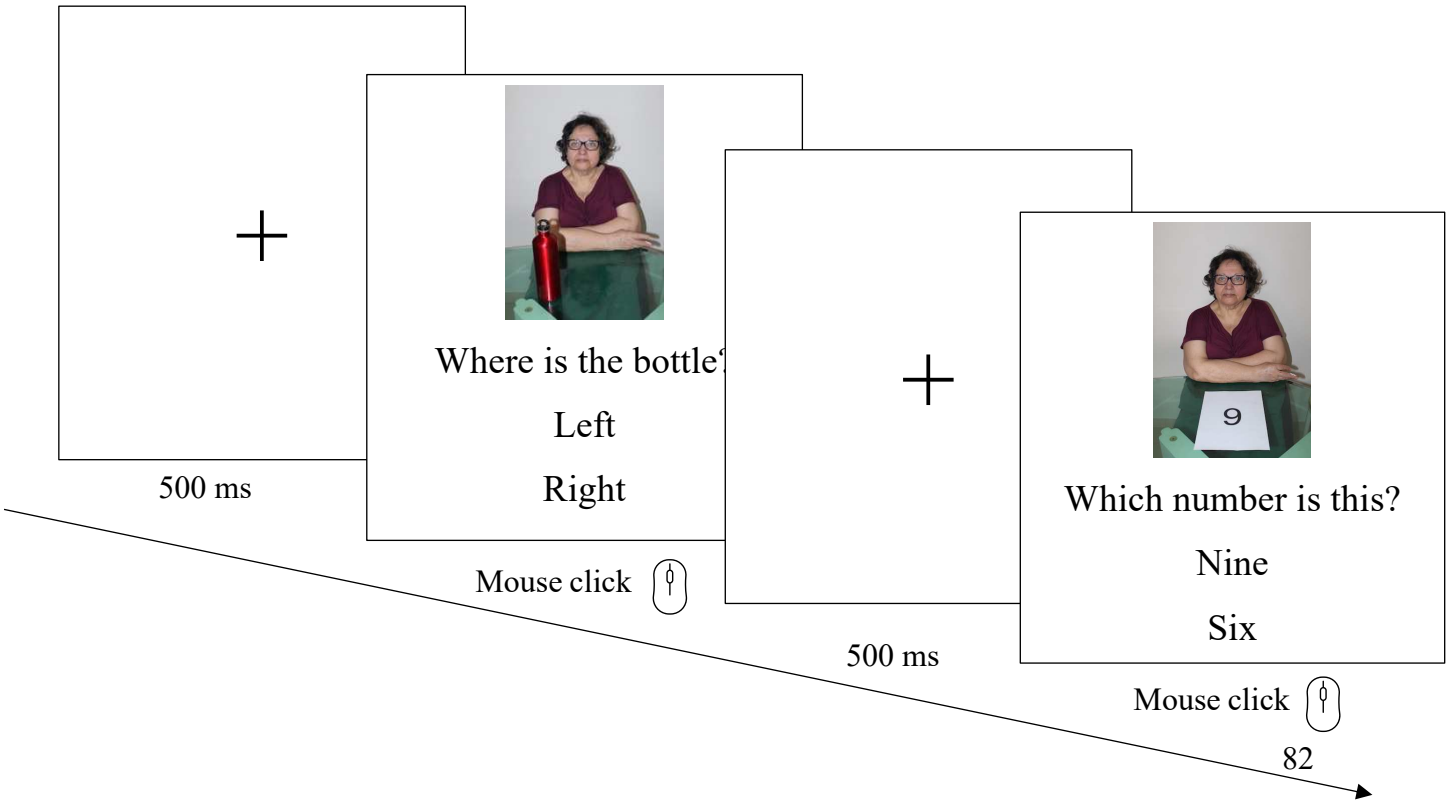
A. Demographic questionnaire:

Participants respond to several questions concerning their age, gender, nationality, origin, city of residence, and level of education (in terms of highest degree obtained).

B. Spontaneous Perspective-taking task:

This task measures the tendency to spontaneously adopt the perspective of another person. It is composed of eight experimental and three filler trials. For each trial, the participants see a fixation cross for 500ms, followed by an image displayed in the center of a computer screen (see Figure 5). The picture shows a person (age and gender correspondence to the participants) looking straight at the camera and sitting behind a table on which an experimental stimulus is placed. Alongside the picture, the participant sees a question and two possible answers, depending on the task category. The subsequent trial appears after the participant chooses an answer by clicking on one of the available options. The individual on the image remains the same throughout the task. At the same time, the experimental stimulus varies across all trials, and their order was randomized for each participant.

Figure 5 : Schematic representation of the task



With the purpose to manipulate the response to the stimulus, participants are randomly counterbalanced into two conditions. Within the first condition, the question is simply placed above the picture. Hence, no expectation of manipulation in this condition. On the other hand, the second condition manipulates the way the question is presented, aiming at eliciting an alter-centric (other) perspective-taking. The question, therefore, emanates from the person through a bubble, mimicking the speech balloons in comics.

Furthermore, the experimental trials are divided into 2 categories (static and movement). The static category is made of 3 task types, i.e., dots, numbers, objects, while the movement category is composed of the stripes task. Each task is presented in two trials.

- The static categories:

  The questions are formulated in a static way.

  - For the dots' task, the experimental stimuli are two sheets of paper containing two or three dots placed in front of the individual in the photo. The participants are asked, "Where do you see the most dots?". The possible answers to choose from are 'left' or 'right'.
  - The numbers' task is readapted from the ambiguous number paradigm (Quesque et al., 2018). In this category, the experimental stimulus is an ambiguous number disposed on a sheet of paper in front of the individual in the picture. The number can be seen as a six or a nine, depending on the perspective. Therefore, the question is "Which number is this?". The proposed answers are 'six' or 'nine'.
  - The objects' task is inspired by the task of Tversky & Hard (2009*)*. The experimental stimuli are, or a water bottle to the right of the person on the image, or a cup to the left of that person. The questions are, respectively, "Where is the water bottle?" and "Where is the cup?". The suggested answers are similar to the dot's task, 'right' or 'left'.

- The movement category:

  The questions are formulated in an active way and implies movement.

  - The stripes task is based on the stripes task in Quesque et al. (2018). In this task type, the experimental stimulus is a paper with multiple-colored stripes arranged horizontally, with a token on the stripe positioned in the middle. For one trial the question is “If the token moves three squares forward, what will be the color of the square it is moving to?”, for the other, “If the token moves three squares backward, what will be the color of the square it is moving to?”. The answers the participant can choose from are ‘yellow’ or ‘red’.

For each task type trial an answer is coded as 1 for an egocentric response, otherwise known as a first-person perspective, and coded as 0 for an alter-centric response, i.e., a third-person perspective. The score of each task type ranges from 0 to 2.

Moreover, the filler trials are a type of control condition to ensure that the subject is maintaining focus on the questions across trials. They take three stimuli from the experimental trials over. One filler uses the dots setting with a different question. In this case, the participant is asked “How many dots do you count?”. The two response options are 'five' or 'four'. Another filler uses the object stimuli but also differs in the presented question. This time the question is, “What is the color of the bottle?”. The potential responses are 'red' or 'blue'. The last filler uses the stripes settings accompanied by the following question: “What is the color of the stripe on which the token is positioned?”. The indicated responses are 'green' or 'yellow'.

A score of 1 is attributed to the participant if they reply correctly to the filler. The filler score is ranged between 0 and 3. The total sum of the fillers is computed to remove the participants that made more than one mistake in the filler trials.

C. Interpersonal Reactivity Index (IRI):

For the purpose of this study, a French version (Braun & Rosseel, 2015), Italian version (Albiero et al., 2006) and Turkish version (Kumru et al., 2004) of the IRI are used, and the participants complete only the seven items of the perspective-taking subscale. This subscale measures the predisposition of a person to assume the point of view of someone else, e.g., "I try to look at everybody's side of a disagreement before I make a decision.".

The participants answer a 5-point Likert scale ranging from 0 (Does not describe me well) to 5 (Describes me very well).

3.2. Procedure

Participants were tested through an online task modality, created on PsyToolKit (Stoet, 2017; version 3.4.3).

First, participants saw a set of instructions telling them that the test was divided in several subcategories, namely, a demographic questionnaire, a task, and a last questionnaire. They were informed that their data would remain anonymous and were asked to consent to the data collection before entering the test. Then a few demographic questionnaires were asked, such as age, nationality, gender, and highest degree obtained. Next, a set of instructions were given to them prior to the task. Finally, after the task they were instructed on how to respond to the statements of the IRI questionnaire and asked to complete it.

4. RESULTS

4.1. Statistical analysis

To be able to explore if spontaneously adopting another person's perspective varies with the category of tasks, culture, and age, we first summed the task trials together. We, thus, started by verifying if the different trials of each task did not differ from one another with a paired wise sample t-test. Then, with the intend to verify if differences between the static tasks (dots, number, object) existed, we computed a univariate ANOVA with the score of each task as the

dependent variable and the task type as independent variables. In case no difference appeared an index score for the static tasks could be created.

The main aim of this study was to investigate if different age groups and nationalities would demonstrate a different pattern of spontaneous perspective taking between static and movement tasks. For this reason, we ran a 2 (tasks: static and movement) within variables x 2 (conditions: simple or speech balloon) x 2 (cultures: individualistic, collectivistic) x 2 (age groups: young or old) between variables repeated measure ANOVA.

We also conducted Pearson correlations between the spontaneous perspective-taking task and the perspective taking subscale of the IRI divided by culture and age groups.

4.2. Regrouping trials and tasks

A paired sample t-test between the two trials of each task demonstrated that there was no difference between the two dots trials (t_{200}=-0.064, p=0.37), number trials (t_{200}=-1.148, p=0.25), object trials (t_{200}=-1.81, p=0.07) and stripes trials (t_{200}=-1.57, p=0.12).

Knowing that there were no differences between the trials of each type we could use the sum of each trial to create a task type. Our final purpose was to compare the movement task to the static tasks, for which we first conducted a univariate ANOVA with the score of the task types (dots, number and object) as dependent variable and the three task types as independent variable. The analysis highlighted that there were no differences between the dots, the number and object tasks ($F_{(2,200)}$=1.28, p=0.28) and could, therefore, be summed together as one static task category.

4.3. Condition, culture, and age group differences in the spontaneous perspective-taking task

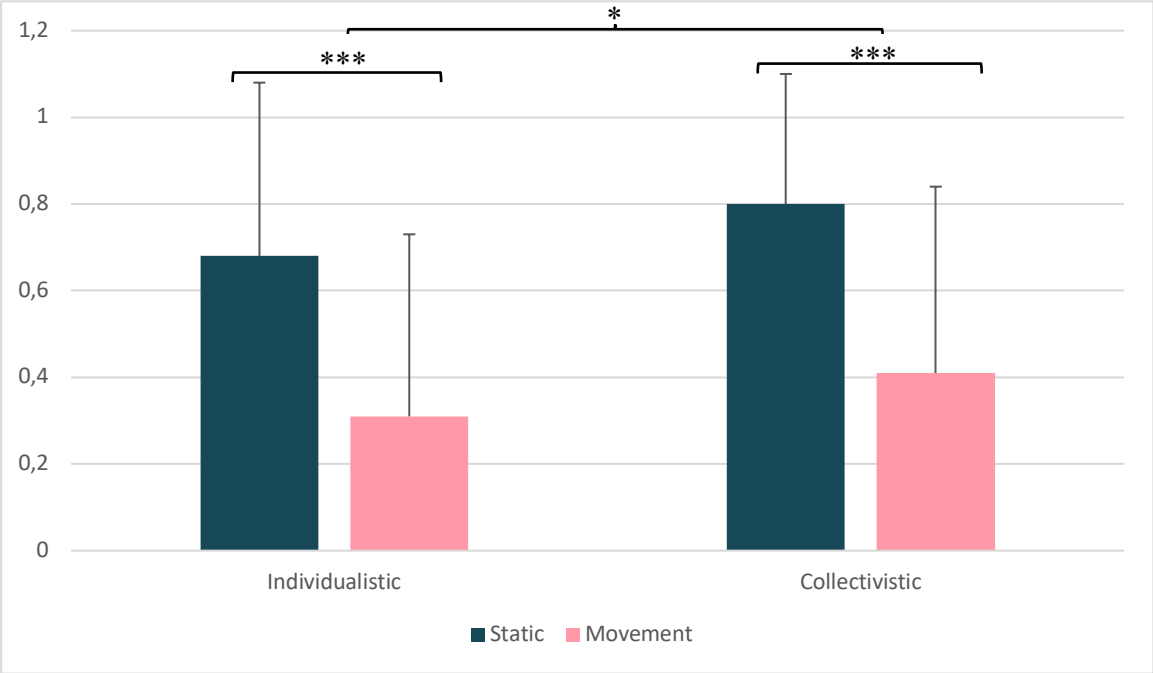
As previously stated, the main aim of this study is to consider if different nationalities, age groups, and question-presenting conditions make a difference in the participants tendency to spontaneously take another person's, also called third person, perspective. Hence, a 2 x 2 x

2 x 2 repeated measure ANOVA with the static and movement task categories as within variables, the 2 conditions (simple question presenting or speech balloon presenting), the 2 cultures (Individualism or Collectivism), and 2 age groups (young or old) as between variables.

No effect of age ($F_{(1,193)}$=0.587, p=0.44), question-presenting condition ($F_{(1,193)}$=0.210, p=0.65), no interaction effect of age and culture ($F_{(1,193)}$=1.03, p=0.312), nor any other kind, were established. On the other hand, an effect of task category ($F_{(1,193)}$=86.79) as well as culture ($F_{(1,193)}$=5.7, p=0.0174) were determined. The post hoc analysis indicated that the participants had a higher tendency to take the other's perspective in the movement category contrary to the static category where participants took their own perspective. Additionally, collectivistic participants tended to take their own perspective more often than individualistic participants (see Figure 6).

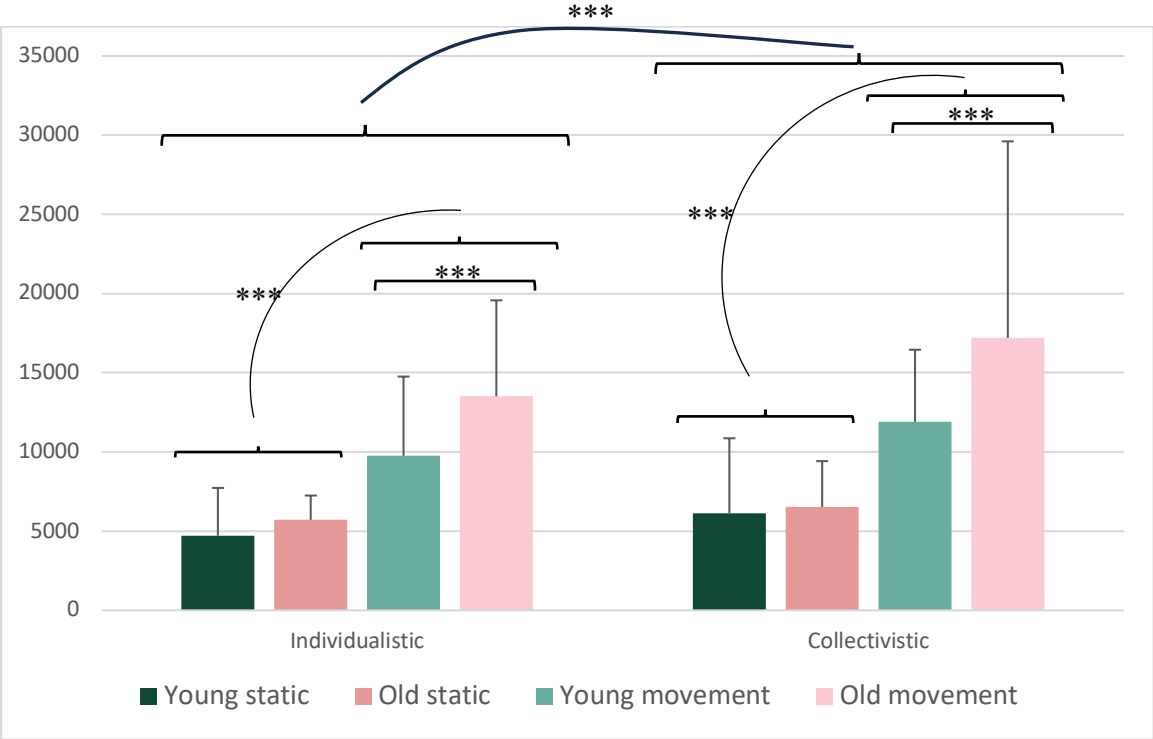
To further investigate the age and cultural differences, we conducted a second 2 x 2 x 2 x 2 repeated measure ANOVA, with in that case, the reaction times of the static and movement task categories as within variables, all other variables being equal. The outcome of this repeated measure ANOVA indicated a main effect of age ($F_{(2,193)}$= 25.45, p<0.001), task category reaction time ($F_{(2,193)}$= 173.43, p<0.001) and culture ($F_{(1,193)}$= 12.68, p<0.001), along with an interaction effect of age and task category ($F_{(2,193)}$= 10.71, p=0.001). Once again no effect of condition ($F_{(2,193)}$= 2.30, p=0.13) was found, nor an interaction effect of age and culture ($F_{(1,193)}$=0.191, p=0.66). The post hoc analysis (see Figure 7) revealed that participants adopted a perspective for static categories faster than for movement categories, and that older adults were slower than younger adults at choosing a perspective, especially in the movement category task. Additionally, collectivistic participants were overall slower at taking a perspective compared to individualistic participants.

Figure 6 : Descriptive statistics (Mean and SD) of the static and movement categories for the three nationalities



A mean close to 0 indicates a majority of first-person perspectives, whereas a mean close to 1 indicates a majority of third-person perspectives. The error bars represent the Standard Deviations.

Figure 7 : Mean and SD of the Reaction times for the static and movement categories for all nationalities



A mean close to 0 indicates a majority of first-person perspectives, whereas a mean close to 1 indicates a majority of third-person perspectives. The error bars represent the Standard Deviations.

4.4.Correlations between IRI perspective taking scale and SPT task

We decided to run some Pearson correlation analyses to investigate the association between a predisposition to be alter-centric and the actual perspective adopted in a spontaneous uncued setting. Since an age difference was found in the IRI questionnaire between the age groups of each culture (individualism: $F_{(1,148)}$=109.95 , p=0.02 ; collectivism: $F_{(1,91)}$= , p=0.02) after running a one-way ANOVA, we decided to run these correlations in the different age-groups of the different cultures. No correlations were found between the IRI items and the two age groups of both the individualistic and collectivistic cultures (see Table 3, Table 4, Table 5, Table 6). Thus, no correlations were found between a spontaneously adopted perspective and the predisposition to take another person's perspective.

Table 3 : Pearson correlations between IRI items and SPT task categories for young adults from the individualistic culture

IRI	Item 3	Item 8	Item 11	Item 15	Item 21	Item 25	Item 28	Total
Static	$r_{(83)}$=0.12	$r_{(83)}$=-0.001	$r_{(50)}$=0.06	$r_{(83)}$=0.02	$r_{(83)}$=-0.07	$r_{(83)}$=0.003	$r_{(83)}$=0.11	$r_{(83)}$=-0.001
Movement	$r_{(83)}$=-0.19	$r_{(83)}$=0.13	$r_{(83)}$=0.03	$r_{(83)}$=-0.17	$r_{(83)}$=0.001	$r_{(83)}$=-0.08	$r_{(83)}$=-0.04	$r_{(83)}$=0.08

Note. (***) p < 0.001, (**) p<0.01, (*) p <0.5, (+) p <0.6

Table 4 : Pearson correlations between IRI items and SPT task categories for old adults from the individualistic culture'

IRI	Item 3	Item 8	Item 11	Item 15	Item 21	Item 25	Item 28	Total
Static	$r_{(50)}$=0.05	$r_{(50)}$=0.09	$r_{(50)}$=-0.03	$r_{(50)}$=0.22	$r_{(50)}$=0.032	$r_{(50)}$=-0.20	$r_{(50)}$=0.02	$r_{(50)}$=-0.13
Movement	$r_{(50)}$=0.21	$r_{(50)}$=0.01	$r_{(50)}$=-0.10	$r_{(50)}$=-0.10	$r_{(50)}$=0.03	$r_{(50)}$=-0.03	$r_{(50)}$=-0.09	$r_{(50)}$=-0.08

Note. (***) p < 0.001, (**) p<0.01, (*) p <0.5, (+) p <0.6

Table 5 : Pearson correlations between IRI items and SPT task categories for young adults from the collectivistic culture

IRI	Item 3	Item 8	Item 11	Item 15	Item 21	Item 25	Item 28	Total
Static	$r_{(25)}$=0.06	$r_{(25)}$=0.03	$r_{(25)}$=-0.13	$r_{(25)}$=-0.10	$r_{(25)}$=-0.14	$r_{(25)}$=-0.16	$r_{(25)}$=0.08	$r_{(25)}$=-0.05
Movement	$r_{(25)}$=-0.18	$r_{(25)}$=0.08	$r_{(25)}$=-0.05	$r_{(25)}$=-0.30	$r_{(25)}$=-0.008	$r_{(25)}$=-0.07	$r_{(25)}$=-0.16	$r_{(25)}$=0.06

Note. (***) p < 0.001, (**) p<0.01, (*) p <0.5, (+) p <0.6

Table 6 : Pearson correlations between IRI items and SPT task categories for old adults from the collectivistic culture

IRI	Item 3	Item 8	Item 11	Item 15	Item 21	Item 25	Item 28	Total
Static	$r_{(26)}$=-0.16	$r_{(26)}$=-0.04	$r_{(26)}$=0.06	$r_{(26)}$=0.09	$r_{(26)}$=0.02	$r_{(26)}$=-0.02	$r_{(26)}$=0.03	$r_{(26)}$=0.02
Movement	$r_{(26)}$=0.19	$r_{(26)}$=0.32	$r_{(26)}$=0.22	$r_{(26)}$=0.13	$r_{(26)}$=0.32	$r_{(26)}$=0.18	$r_{(26)}$=0.24	$r_{(26)}$=0.23

Note. (***) p < 0.001, (**) p<0.01, (*) p <0.5, (+) p <0.6

5. DISCUSSION

Literature indicated that perspective-taking worsens with age (Healey &Grossman, 2016; Martin et al, 2019b; Mattan et al., 2017; Saryazdi et al., 2020). Research highlights that older adults tend to adopt an egocentric perspective and have an egocentric interference when they take an alter-centric perspective (Mattan et al., 2017; Martin et al., 2019b). Furthermore, cultural differences in perspective-taking have been researched approving multiple theories.

The goal of this study was to investigate the age and cultural differences to spontaneously take a third-person perspective between young and old adults from individualistic and collectivistic cultures. With this aim in mind, we created an uncued task to elicit spontaneous perspective taking. Several angles were examined such as the two question presenting conditions, where the speech balloon condition was designed to create a more interactive approach, in the hope to manipulate the participants to take the alter-centric

perspective. We supposed that older adults would be even more inclined to take a self-perspective than younger adults.

Contrary to our expectations and the literature (Healey & Grossman, 2016; Mattan et al., 2017; Saryazdi, 2020), the analysis demonstrated that no significant differences were found between young and old adults in the perspective they adopted in the different spontaneous perspective tasks. Both age groups tended to take a first-person perspective in the static task categories and a third-person perspective in the movement category. We hypothesize that our task design could have evaluated the basic process of perspective-taking and that since this process happened unconsciously and involuntarily, it did not require working memory or executive functions abilities. Nonetheless, older adults took significantly more time to spontaneously adopt a third-person perspective compared to younger adults. This could be due to an egocentric interference as seen in the literature (Martin et al., 2019b). Therefore, even if the tendency of perspective-taking is the same between younger and older adults, the latter seem to struggle more in taking an alter-centric perspective. These results need to be further investigated by exploring the underlying mechanism, to understand the reasons behind this lack of age-related differences.

On the other hand, our analyses exposed a main effect of the task categories signaling that the perspective-taking tendency changed for the movement category. This result is in line with the literature (Tversky & Hard., 2009), demonstrating that a movement-oriented demand elicits a greater alter-centric perspective. This study reveals that movement influences perspective-taking for younger as well as older adults.

Interestingly, the results reported that the collectivist sample tended to favor an egocentric perspective, which reinforces the representational hypothesis of Wu and Keysar (2007), in both the static and movement task categories. For the collectivistic sample 80% of the participants took an egocentric perspective in static phrased demands tasks and 40% in the

movement phrased demands. Contrary to the individualistic participants out of which only 68% took a first-person perspective in the static phrased categories and 31% in the movement phrased ones. The longer reaction time of the collectivistic participants compared to the individualistic participants in the movement categories, emphasize the endorsement of the representational hypothesis and could indicate an egocentric interference as seen in Martin and colleagues (2019a) research. Curiously, no interaction effects between task type and culture or age and culture were found. Unfortunately, our condition manipulation had no effect either and was maybe not strong enough in the overall design to create a difference which could be defined as a limit of this study.

Moreover, we considered a possible correlation between the self-reported predisposition to take an alter-centric perspective and to spontaneously adopt an alter-centric or egocentric perspective in the different age groups of each culture. No correlations were found neither in static tasks where the participants tended to take the first-person perspective nor in the static movements where the participants tended to take the third-person perspective. These results could be due to the automaticity of the response in the SPT, whereas people are explicitly asked to take a perspective in the questionnaire. It would thus not target the same tendencies.

Another limitation to this study is the use of only one movement category task confronted with three static category tasks. More types of demand phrasings should be added, such as different types of movement-oriented phrasings, an animated object with static and movement phrasings, or a feeling of movement from the individual on the picture. A final limitation could be the divergent number of participants recruited for the individualistic and collectivistic cultures.

Overall, this study suggests that younger and older adults both tend to spontaneously take a first-person perspective in static phrased situations and a third-person perspective when a movement is implied. So, older adults did not exhibit any significant differences in

spontaneous perspective-taking compared to younger adults. Moreover, the results of this research pointed a greater adoption of the egocentric perspective in the Turkish population, which advocates the representational hypothesis of Wu and Keysar (2007) and the study of Martin et al. (2019a).

Hence, future studies should examine the underlying mechanisms of this type of uncued spontaneous perspective-taking in aging, confronting it with implicit and explicit perspective tasks, along with cognitive control tasks of mental rotation and executive functions. Moreover, future studies should continue to investigate the cultural-related differences in such a task.

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SECTION 2. Social functioning and its association to social cognition

Chapter V. *Section guide*

Theoretical issues

We will start with a small recap of the main results of the previous section. In chapter III, we discovered that older adults tend to manifest lower ToM abilities in comparison to younger adults despite the diversified ToM tasks and their parameters. Furthermore, chapter IV evidenced that older adults have the same tendency in perspective-taking as younger adults. Although, a higher egocentric bias in older adults was determined by the reaction time of their responses. Now, this section will consider social functioning and its association to social cognition more in depth.

As previously defined, social functioning is our ability to adapt and appropriately engage in day-to-day social exchanges (Bosc, 2000; Bottema-Beutel et al., 2019; Hirschfeld et al., 2000). For the sake of this thesis, we will evaluate social functioning through reciprocal behavior given that reciprocity is a relevant response to a previous social behavior of our interlocutor or, more generally, interacting partner (Moore & Barresi, 2017; Voelkl, 2015). Due to the socioemotional theory, we know that older adults tend to reduce their interaction partners preferring to keep contact with close relatives. The studies on perceived reciprocity (Braun et al., 2018; Wahrendorf et al., 2010) are in line with this theory stating that older adults weigh the balance in reciprocity with their spouse and relatives as more important than with neighbors or, worse, strangers. However, these studies rely on self-report questionnaires and perception.

Bailey and colleagues (2008) highlighted the effect of the deterioration in social cognition on the decline in social functioning and underlined that this relationship was bidirectional. Nevertheless, studies mainly focussed on how the lack of social interactions affect ToM (Pearlman-avnion et al., 2018). Most studies on the association between reciprocity and ToM were performed on children (Shug et al., 2016; Zhang et al., 2019) and adults (Sun et al.,

2020). Nonetheless, a ToM task was used by Calso and colleagues (2019) to study reciprocity in older adults, but no distinction was made between the ToM items and the reciprocity items.

With all this in mind, this section will start by comparing the reciprocal detection of younger and older adults in Chapter VI and go further by analyzing age-related differences in reciprocal behavior between younger and older adults. The aim of the chapter will be to bridge the gap on social functioning performance in older adults. In chapter VII we will go one step further and analyze reciprocal behavior through an interactive task. Additionally, both studies will interrogate the association between reciprocity, as a measure of social functioning, and ToM, as a cognitive ability.

The main measures employed

The Mind Picture Story – Theory of Mind Questionnaire (MPS-TOMQ)

This task was first created to assess ToM in schizophrenic patients in a non-verbal task (Brüne, 2003). Calso et al. (2019) took the task over and adapted the cartoons to resemble older adults daily social encounters. This task is of particular interest in this thesis due to its evaluation of several dimensions of reciprocity, namely, deception, cooperation and cheating.

The Interactive Drawing task (IDT)

The IDT (Backer van Ommeren et al., 2017) was initially created to diagnose autism spectrum disorder (ASD) in children through a social interactive task eliciting reciprocity since ASD individuals exhibit a lack of reciprocal behavior. No explicit instructions are given to the participant to mirror real life social situations and leave space to spontaneous behaviors. The experimenter follows specific directions to implicitly induce reciprocal behaviors and applies them to every drawing.

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Chapter VI. Study 3 - Cognitive functions, Theory of mind abilities, and personality dispositions as predictors of the detection of reciprocity in deceptive and cooperative contexts through different age groups.

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1. ABSTRACT

To detect the three dimensions of reciprocity, namely, cooperation, deception and cheating is an important competence to maintain good social relationships and to be able to properly react to a social interaction or avoid being taken advantage of. Older adults have shown to have a lower ability to detect cooperation and deception compared to younger adults, partially tying this decline to cognitive functions. On the other hand, personality dispositions such as agreeableness, altruism and empathic concern have been associated to reciprocity. Therefore, this study aimed at investigating age-related differences in the detection of the different components of reciprocity, as well as examining the predictors of reciprocity, such as cognitive measures, personality dispositions, and true and false beliefs. A sample of 98 younger adults, 106 middle aged adults and 103 old adults answered to several personality questionnaires, cognitive tasks of reasoning and working memory, and a false belief and reciprocity task named Mind Picture Story - Theory of Mind questionnaire. Older adults indicated a decline in detecting cooperation and deception compared to younger adults. Personality dispositions and cognitive functions significantly predicted the ability to detect the reciprocity components depending on the age group. For younger adults' personality dispositions played an important role, which faded with age, while cognitive functions became more significant predictors.

Keywords: Reciprocity, Theory of Mind, Personality, cooperation, deception, cognitive functions

2. INTRODUCTION

Reciprocity is a fundamental component of human social interactions and is of particular importance in aging to maintain participation and connectedness with their community (Emlet & Moceri, 2012). It can be described by a continuance of shared and appropriate social behaviors between interacting individuals (Moore & Barresi, 2017; Voelkl, 2015). It can take multiple forms and be direct, indirect, or generalized. Direct reciprocity is based on the ongoing interaction between two protagonists (Schmid et al. 2021). On the other hand, indirect reciprocity is based on reputation, it is a continuous evaluation of each other's behavior by all the actors who contribute to maintaining the collective system (Molm, 2010; Schmid et al., 2021; Schweinfurth & Call, 2019). Alternatively, generalized reciprocity is about the overall social interactions an individual had in the past, it's a chain of reciprocal behavior where a person reciprocates behaviors of previous interaction partners to following interaction partners (Molm, 2010; Sun et al., 2020).

Since reciprocity includes an expectation of a symmetrical response to an event, a sort of tit-for-tat, it is of great importance to detect if others will cheat, deceive, or cooperate. The detection of cheating, deception, and cooperation is of greater importance for older adults, who seem to be more vulnerable to social tricks (James et al., 2014). In fact, older adults exhibit a lower detection of cooperation and deception than younger adults (Calso et al., 2019a; Calso et al., 2019b). Interestingly, these abilities depend on cognitive functions. Indeed, reciprocity is cognitively demanding since it requires remembering the reciprocal behavior of others and maintaining a balance in behaviors (Brosnan et al., 2010; Schweinfurth, 2019). Working memory and reasoning seem to be two critical abilities involved in such behavior (Stevens et al., 2005).

Moreover, reciprocal behavior requires people to understand and reason about others' intentions and beliefs, which is defined as Theory of Mind (ToM; Lissek et al., 2008). More

specifically, it's important to distinguish true from false beliefs. A cooperative person will demonstrate coherence between his intentions and actions which will generate a true belief, while a deceptive person hides the real intentions of their actions by generating a false belief about their behavior. Therefore, being able to detect deception or cooperation depends on your ability to reason on beliefs. Accordingly, both ToM and cognitive abilities may be associated with performance in reciprocal behavior, detection, and perception.

Additionally, as reciprocity involves the interaction between at least two people, dispositional factors, such as personality traits, altruism, and empathic concern, could explain reciprocal behavior. Regarding traits, one of the most relevant ones involved in social interaction is agreeableness, part of the Big Five personality construct. It combines the dimensions of cooperation, kindness, politeness, and friendliness. Moreover, a correlation between agreeableness and reciprocity emerged from the literature (Perugini et al., 2003; Thielmann & Hilbig, 2015). For example, Sabater-Grande et al. (2022) in their economic study on the Trust Game, found that a higher propensity to agreeableness is associated with a higher probability for reciprocal behavior.

Interestingly, according to Perugini and colleagues (2003) all the dimensions of altruism correlate with reciprocity as well. Altruism is associated positively with positive reciprocity and negatively with negative reciprocity.

The literature contains several studies focused on deception in aging because older adults are easy targets of scams. However, no study looked at cooperation, deception, and cheating as essential components of reciprocity. Nonetheless, Raimo and colleagues (2022) investigated deception and cooperation as a factor of cognitive ToM. Moreover, studies on reciprocity focus more on perception and beliefs (Braun et al., 2018; Wahrendorf et al., 2010) rather than performance. There is limited research on the association between reciprocity and its predictors. For example, the role of personality dispositions has been associated with reciprocity in

economic games and adult populations (Zhao et al., 2016). This study decided to focalize on the performance of these various components.

Hence, the main aim of the present study was the investigation of age-related differences in reciprocity by using a task simultaneously measuring the performance in several aspects of reciprocity: deception, cheating, and cooperation. Despite the relevance of investigating reciprocity in aging, few studies have analyzed it by comparing different age groups. Therefore, this study includes three age groups, younger, middle-aged, and older adults, to identify the origin of the decline in the detection of cooperation, deception, and cheating. To measure these possible age-related differences, we used a ToM task measuring the components of reciprocity.

As the literature reports a disengagement of older adults towards reciprocity (Braun et al., 2018) we expect older adults to have a lower performance in all the reciprocity dimensions compared to middle-aged and younger adults. We also expect that the distinct types of stories in which the reciprocity dimensions can be detected will show divergent patterns of results due to the specific cognitive traits linked to them (Phillips et al., 2011). For example, older adults will have particular difficulties in mixed stories because they are more cognitively demanding since they combine all the dimensions of reciprocity in one story.

The second aim was to investigate whether cognitive abilities, such as reasoning and working memory, personality dispositions (i.e., agreeableness, altruism, and empathic concern), and true and false beliefs predict reciprocity performance and if these associations are different in the three age groups as a function of age.

As reciprocity is a cognitively demanding construct, we expect the cognitive measures to be a high predictor of detecting the components of reciprocity, especially in older adults. Steward and colleagues (2018) determined that detecting truth relied on attentional resources while according to Sporer (2016) deception is likely linked to working memory. Therefore, reasoning would be a predictor of cooperation, and working memory a predictor of deception.

For the personality dispositions, we expect the personality dimensions to lose relevance through age as cognitive functioning is shown to be more associated to vulnerability to social tricks in aging (Judges et al., 2017). We hypothesize that a person with a higher degree of empathic concern would be better at detecting a situation of deception or cheating. Indeed, empathic concern is characterized by experiencing feelings of warmth and compassion for individuals experiencing negative situations, such as a feeling of protection for people that are taken advantage of. In spite of the fact that no direct link has been found in the literature.

We also expect true belief understanding to predict cooperation detection, while false belief would be a predictor of deception detection due to the nature of the concepts highlighted previously. Since ToM is a socio-cognitive concept and reciprocity is a social functioning concept, we expect that true and false beliefs will be strong predictors of the reciprocity dimensions. We suppose that this association is stronger in older adults for whom a decline in socio-cognitive abilities induces a decrease in social functioning (Brunsdon et al., 2021).

3. METHOD

3.1. Participants

The study involved 306 participants divided into three age groups: 98 younger adults (48 women, age range: 20-39, M=27.43, SD= 5.51), 106 middle-aged adults (58 women, age range: 40-64, M=53.14, SD=6.71) and 103 community-dwelling older adults (53 women, age range: 65-96, M=74.83, SD=8.03). The participants were recruited through word-of-mouth and participated voluntarily. All participants were Italian. Older adults underwent screening for signs of dementia before the tasks. Consequently, older adults with a mini-mental state examination (MMSE; Folstein et al., 1975) score lower than twenty-four were excluded from this study. There was a difference in education between all three age groups ($F_{(2,304)}$=49.1, p<0.001), younger adults (M=15.48, SD=2.66) had a higher level of education than middle-

aged adults (M=13.30, SD=3.40) and both young and middle-aged adults had a higher level of education than older adults (M=10.5, SD=4.42).

We measured the crystalized ability of our sample through a vocabulary test (Primary Mental Ability; Thurstone & Thurstone, 1963), for which no significant age differences were found (M_{young}=40.12, SD_{young}=6.45, $M_{middle\ aged}$=40.97, $SD_{middle\text{-}aged}$=8.40, M_{old}=38.63, SD_{old}=9.58, $F_{(2,304)}$=2.136, p=0.12).

3.2. Cognitive measures

A. Reasoning

We measured reasoning through Raven's Progressive Matrices test (RPM) (Raven & Raven, 1983). RPM is a non-verbal assessment of abstract reasoning, containing 48 items divided into four series (ranging from A to D) of 12 items each. Each item consisted of a geometric design missing a piece. The participant must select the missing piece that would complete the geometric design out of six or eight given choices. Responses were scored 1 for a correct answer and 0 for an incorrect answer (possible range 0-48).

B. Working memory

The Backward Digit Span task (drawn by Wechsler Adult Intelligence Scales; Wechsler, 1981) was used as a standardized measure of working memory. First, digit sequences extending from 2 to 8 digits are presented orally to the participants. They are then asked to repeat it in inverted order. The overall score consists of the total number of correctly recalled digits prior to failing two consecutive sequences at any one span size. Possible scores can range from 2 to 8.

3.3. Reciprocity detection and ToM competences

The detection of cooperation and ToM abilities were assessed with a non-verbal task, the Mind Picture Story - Theory of Mind Questionnaire (MPS-TOMQ) of Calso and colleagues (2019a) based on the Theory of Mind Picture Story task (TMPS) of Brüne (2003). We decided

to use the version of Calso et al. (2019a) because they slightly modified the pictures and stories to depict older characters and familiar situations to older adults. This task examines the ability to detect deception and cooperation in the context of deception (negative) and cooperation (positive), along with ToM performance assessing the ability to understand false and true beliefs. Thus, the task is composed of six stories: two deception stories, two cooperation stories, and two mixed stories portraying both cooperation and deception, and each story, is formed by four pictures.

As a first step, the experimenter placed the four pictures of each story in front of the participant in a mixed order. The participant is then asked to organize the pictures in a meaningful sequence to form the story. This part is the Mind Picture Story (MPS) and was evaluated through accuracy and reaction time. The participant was timed while placing the pictures together and a score is given to the sequence in which the pictures are placed.

A score of two points was given for the correct sequence of the first and fourth pictures each and a score of one point for the third and fourth pictures, respectively if correctly placed. Thus, each story was scored on a range from zero to six. The total MPS score for the six stories ranged between 0 and 36.

Once the participant completed the logical sequencing of the pictures, the experimenter evaluated if the sequence was correct and if not, put them in the exact order.

The second part of the task consisted of a series of questions on the story evaluating the detection of cooperation and deception, and multiple aspects of ToM (first, second-, and third-order beliefs and false beliefs). This part is called the Theory of Mind Questionnaire (TOMQ) and is originally divided into nine subscales, which we decided to maintain: reality, first-order true belief, first-order false belief, second-order true belief, second-order false belief, third-

order false belief, cooperation, deception, and cheating. This questionnaire contains 24[1] items, two reality items, two first order true belief items, three first order false belief items, two second order true belief items, three second order false belief items, two third order false belief items, four cooperation items, four deception items, and two cheating items. The cooperation and deception items are in the cooperation and the deception stories, respectively, but also in the mixed stories.

Unlike the original scoring, we decided to score every item between zero (the answer is not correct), one (partially correct), and two (completely correct). Each subscale was scored separately, and their range depends on the number of items.

These two parts are repeated for each story and the total score of the MPS-TOMQ is between 0 and 84.

3.4. Personality dispositions

We investigated three different types of personality dispositions: altruism, empathic concern, and agreeableness.

A. Big Five Questionnaire (BFQ)

We measured agreeableness through the 24 items of the Agreeableness scale of the Big Five questionnaire (Caprara et al., 1993), which assesses the disposition to be cooperative, polite, kind, and friendly. The Italian version of the Big Five Agreeableness trait is divided into two dimensions which are cordiality and cooperativeness. Items were rated on a scale ranging from 1 (*very inaccurate*) to 5 (*very accurate*).

B. Elderly Care Research Center (ECRC) altruistic scale

Altruism was estimated by the ECRC altruistic scale (Bhatta et al., 2021) to evaluate altruistic attitudes and orientations. The ECRC Altruistic scale consists of 5 items (e.g., “I enjoy

[1] To investigate reciprocity in positive and negative settings and to have the same number of reciprocity and deception items, we added a reciprocity question in one of the mixed stories.

doing things for others", "I try to help others, even if they do not help me") gauged on a 5-point Likert scale (namely, *strongly disagree* = 1, *disagree* = 2, *neither agree nor disagree* = 3, *agree* = 4, *strongly agree* = 5).

C. Interpersonal Reactivity Index (IRI)

To evaluate empathic concern, we used the Italian version of the empathic concern subscale from the IRI (Davis, 1980). This subscale contains seven items quantified by a 5-point Likert scale ranging from 0 (Does not describe me well) to 5 (Describes me very well). This subscale determines the participants' tendency to experience feelings of concern or compassion towards others.

3.5. Procedure

Participants were tested individually during two sessions. In the first session, after obtaining consent, participants first compiled a brief demographic questionnaire, and only participants over 65 years old underwent the MMSE to ensure eligibility for the study (MMSE > 24). Then, participants performed the vocabulary test and the Backward Digit Span. Subsequently, they completed the Agreeableness scale of the BFQ, empathic concern subscale of the IRI, and the ECRC altruistic scale. In the second session, participants carried out the MPS-TOMQ task and the Raven's Progressive Matrices.

4. RESULTS

4.1. Statistical analysis

Intending to identify age-related differences between the three age groups, we computed various one-way analyses of variances (ANOVAs) on background variables (i.e., years of education, vocabulary), cognitive measures (namely, working memory and reasoning), and personality dispositions (i.e. altruism, empathic concern and the two dimensions of agreeableness: cordiality and cooperativeness). However, we ran analyses of covariances

(ANCOVAs) on the cooperation, deception, cheating and ToM items from the MPS-TOMQ task to examine possible age group differences controlling for years of education.

Next, we used separate hierarchical multiple linear regression analyses to investigate which variables predicted the detection of cooperation, deception, and cheating in the three age groups.

All analyses were performed using Rstudio version 4.1.2 (2021).

4.2. Age-related differences in cognitive measures

Descriptive statistics are presented in Table 7 split by age groups. The results of the one-way ANOVAs and post hoc analyses indicated age-related differences in abstract reasoning ($F_{(2,304)}$= 67.56, p<.001) and working memory ($F_{(2,304)}$=30.39, p<.001) between all age groups. We can see a declining trend between the different age groups, with each group displaying a better cognitive performance than the more advanced age group.

Table 7 : cognitive measures descriptive statistics by age group

	Younger adults (N = 98)		Middle-aged adults (N=106)		Older adults (N=103)	
	Mean (SD)	range	Mean (SD)	Range	Mean (SD)	Range
Reasoning	42.87 (3.72)	27-49	39.25 (***) (5.17)	14-47	32.29 (***, +++) (9.37)	5-47
Working memory	5.37 (1.33)	2-8	4.77 (**) (1.25)	2-8	3.91 (***, +++) (1.42)	1-8

Note. A significant difference from the young adult group is represented by (***) p<.001, (**) p<.01, (*) p<.05; A significant difference from the middle-aged group is represented by (+++) p<.001, (++) p<.01, (+) p<.05.

4.3. Age-related differences in the different personality dispositions

The descriptive statistics for all the personality dispositions can be found in Table 8.

No significant age differences were found in the overall agreeableness scale ($F_{(2,304)}$=.69, p=.50), but there was a marginal age difference found for cordiality ($F_{(2,304)}$=2.36, p=.096) but

not cooperativeness ($F_{(2,304)}$=1.65, p=.193) when agreeableness was subdivided into its two dimensions. Older adults scored marginally higher on the cordiality dimension scale than younger adults. However, old and middle-aged adults demonstrated a significantly greater altruistic attitude ($F_{(2,304)}$=12.52, p<.001) and a higher tendency towards empathic concern ($F_{(2,304)}$=7.45, p<.001) than younger adults.

Table 8 : Descriptive statistics for the personality dispositions divided by age group.

	Younger adults (N = 98)		Middle-aged adults (N=106)		Older adults (N=103)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Agreeableness	79.12 (11.02)	47-101	80.80 (10.04)	46-108	80.39 (10.67)	56-102
Cordiality	36.73$^{(.)}$ (6.83)	22-50	37.71 (6.00)	23-54	38.69 (6.30)	23-54
Cooperativeness	42.39 (5.42)	24-51	43.09 (5.56)	23-54	41.7 (5.65)	28-54
Altruism	17.79 $^{(***,+++)}$ (3.19)	10-25	19.58 (3.13)	12-25	19.87 (3.25)	10-25
Empathic concern	26.1$^{(***,+)}$ (4.05)	16-35	27.52 (4.46)	16-35	28.38 (4.10)	18-35

Note: A significant or marginal difference from the old adult group is represented by (***) p<.001, (**) p<.01, (*) p<.05, (.) p<.1; A significant difference from the middle-aged group is represented by (+++) p<.001, (++) p<.01, (+) p<.05.

4.4. Age-related differences in the MPS-TOMQ task

Table 9 will provide the descriptive statistics of all the items scores of the MPS-TOMQ task. One of the main aims of this study was to examine if there were age-related differences in the detection of cooperation, deception and cheating and in false belief understanding. As previously acknowledged, our sample demonstrated a significant age-related difference in years of education between all age groups. For this reason, various ANCOVAs controlling for years of educations and post hoc analyses were conducted on all the items of the task.

For the detection of cooperation only a marginal effect of age was revealed ($F_{(2,302)}$=2.45, p=.088) with no effect of years of education ($F_{(1,302)}$=.23, p=.63), showing that middle aged adults detected cooperation marginally better than older adults. When the cooperation variable was subdivided into type of stories a significant age group difference emerged for cooperation in cooperation story ($F_{(2,302)}$=3.93, p=.021) with no effect of years of education ($F_{(1,302)}$=1.10, p=.30), while no differences among the age groups were found in cooperation in mixed stories ($F_{(2,302)}$=.49, p=.62) but a marginal effect of the level of education ($F_{(1,302)}$=3.84, p=.051) was present. Both younger and middle-aged adults displayed a greater detection of cooperation in cooperation stories than older adults. On the other hand, a main effect of age groups was present for deception detection ($F_{(2,302)}$=4.86, p=.0084) in general, but also when subdivided by type of story (deceptive story: $F_{(2,302)}$=3.51, p=0.031; mixed story: $F_{(2,302)}$=5.14, p=.0064), with no effect of years of education on all the items (deception: $F_{(1,302)}$=.78, p=.38; in deceptive story: $F_{(1,302)}$=1.003, p=.32 ; in mixed story: $F_{(1,302)}$=.068, p=.79). The post hoc analysis divulged that, younger and middle-aged adults exhibited a better deception detection compared to older adults. Instead, younger adults showed a significantly greater ability to detect deception in a deceptive story and marginally superior in mixed stories compared to older adults. Middle aged adults were marginally more able to identify deception in deceptive stories and significantly more in mixed stories than older adults. Similar results

were observed for the detection of cheating ($F_{(2, 302)}$=5.99, p=.04), with a marginal effect of years of education ($F_{(2,302)}$=3.43, p=.065). The ability for younger adults to detect cheating was significantly higher than for older adults.

Regarding the ToM items of the task, the ANCOVA analyses showed significant effects of age groups for the reality ($F_{(2,302)}$=4.63, p=.01) and third-order false belief ($F_{(2,302)}$=4.54, p=.011) items, where the covariate, years of education, was not significant (reality: $F_{(1,302)}$=1.46, p=.23; 3rd order FB: $F_{(1,302)}$=.017, p=.90). In both these items, younger adults displayed a significantly better understanding and middle-aged adults a marginally greater understanding than older adults. Furthermore, second-order false belief ($F_{(2,302)}$=4.77, p=.0091) items and the sequencing score ($F_{(2,302)}$=8.01, p<.001) showed age-related differences, although the years of education appeared to be significant ($F_{(1,302)}$=4.04, p=.045; $F_{(1,302)}$=13.22, p<.001, respectively). Younger adults had a marginally higher understanding of second-order false beliefs, whereas middle aged adults were significantly better than older adults. The opposite applies to the reality items were younger adults manifested a superior understanding and middle-aged adults a marginally higher understanding than older adults. Interestingly, the second-order belief and the first-order false belief items displayed an effect of years of education (2nd order true belief: $F_{(1,302)}$=5.90, p=.016; 1st order false belief: $F_{(1,302)}$=4.92, p=.027) but no effect of age groups (2nd order true belief: $F_{(2,302)}$=1.53, p=.22; 1st order false belief: $F_{(2,302)}$=.37, p=.69). Whereas the first-order true belief items showed a marginal effect of age groups ($F_{(2,302)}$=2.53, p=.081) and no effect of years of education ($F_{(1,302)}$=.83, p=.36).

Predictably a main effect of age groups ($F_{(2,302)}$=9.91, p<.001) and years of education ($F_{(1,302)}$=10.49, p=.0013) arose on the total MPS-TOMQ score. Indeed, younger, and middle-aged adults performed significantly better than older adults on the different items overall.

Table 9 : Adjusted descriptive statistics for the MPS-TOMQ task divided by age group.

	Younger adults		**Middle-aged adults**		**Older adults**	
	Mean (SE)	Range	Mean (SE)	Range	Mean (SE)	Range
Sequencing (MPS)	27.8 (0.575)	16-36	27.52 (0.517)	17-36	24.7 (**, ++) (0.569)	11-36
cooperation	6.77 (0.151)	4-8	6.84 (0.136)	4-8	6.40 (§) (0.149)	1-8
cooperation story	3.38 (0.0972)	1-4	3.36 (0.0874)	1-4	3.03 (*, +) (0.0963)	0-4
mixed story	3.39 (0.0892)	1-4	3.48 (0.0802)	1-4	3.37 (0.0884)	0-4
deception	4.73 (0.170)	2-7	4.69 (0.153)	2-7	4.05 (*, +) (0.169)	0-7
deception story	2.25 (0.129)	0-4	2.14 (0.116)	0-4	1.76 (*, §) (0.128)	0-4
mixed story	3.19 (0.0635)	2-4	3.24 (0.0571)	1-4	2.97 (·, ++) (0.0629)	0-4
cheating	3.17 (0.1039)	1-4	3.07 (0.0934)	0-4	2.79 (*) (0.1028)	0-4
1st order TB	2.59 (0.1073)	2-4	2.86 (0.0964)	0-4	2.61 (0.1063)	0-4
1st order FB	4.48 (0.122)	2-6	4.40 (0.110)	2-6	4.33 (0.121)	2-6

2nd order TB	3.53 (0.0762)	2-4	3.70 (0.0685)	1-4	3.61 (0.0755)	0-4
2nd order FB	5.08 (0.153)	2-6	5.16 (0.137)	1-6	4.55 (., ++) (0.151)	0-6
3rd order FB	3.20 (0.147)	0-4	2.97 (0.132)	0-4	2.55 (**,§) (0.145)	0-4
reality	3.23 (0.115)	0-4	3.08 (0.104)	0-4	2.72 (*,§) (0.114)	0-4
MPS-TOMQ	64.5 (1.089)	47-82	64.2 (0.979)	43-82	58.3 (***, +++) (1.078)	28-81

Note. TB = true belief; FB = false belief

A significant or marginal difference from the young adult group is represented by (***) $p<.001$, (**) $p<.01$, (*) $p<.05$, (.) $p<.1$; A significant or marginal difference from the middle-aged group is represented by (+++) $p<.001$, (++) $p<.01$, (+) $p<.05$, (§) $p<.1$

4.5. Regression analysis in the different age groups

To examine potential predictor effects of personality dispositions, cognitive measures, and true and false belief items on reciprocity, deception, and cheating detection in younger, middle-aged, and older adults, we applied hierarchical regression analyses with three stages (detailed in Table 10, Table 11, Table 12). The first step only included personality dispositions, namely, the two dimensions of agreeableness, i.e., cordiality and cooperativeness, empathic concern, and altruism as predictors. Step 2 added the cognitive measures of working memory and reasoning to the predictors. In step 3 true belief items were added as predictors for the cooperation items and false belief items were added as predictors to the deception detection items as suggested by the literature (Lissek et al., 2008).

In the younger adults' sample, in the first step the model was never significant for none of the outcome variables. Adding the cognitive measures was significant and increased R^2

significantly in cooperation in mixed story ($F_{(6,91)}$= 3.592, p=0.003), deception ($F_{(6,91)}$=3.747, p=0.002), deception in mixed story ($F_{(6,91)}$=2.207, p=0.049) and cheating ($F_{(6,91)}$=2.214, p=0.049). The model approached significance and R^2 variated significantly in cooperation ($F_{(6,91)}$=2.091, p=0.062). Working memory was a positive and significant predictor for all these variables. The ToM items of belief in the third step added significance to the model and a significant variation of R^2 in deception ($F_{(9,88)}$=6.571, p<0.001), deception in deception story ($F_{(9,88)}$=6.618, p<0.001) and cheating ($F_{(9,88)}$=3.279, p=0.002) and a marginal variation for cooperation ($F_{(9,88)}$=2.243, p=0.031). Second and third order false belief were predictors of deception in deception story, and only third order false belief remained a positive predictor of deception. Whereas first- and third-order false belief significantly predicted the detection of cheating, respectively, negatively and positively. In this third step empathic concern remained predictive only in cooperation in mixed story. Working memory stayed a significant predictor for deception and a close to significant predictor for cooperation and cooperation in mixed story

The regression models in the middle-aged group showed that the first step of the model concerning the personality dispositions were not significant for any of the outcomes. The addition of the cognitive measure in the second step variated R^2 significantly in cooperation ($F_{(6,99)}$=2.325, p=0.038), deception ($F_{(6,99)}$= 9.894, p<0.001), deception in deception story ($F_{(6,99)}$=3.324, p=0.005), deception in mixed story ($F_{(6,99)}$=7.127, p<0.001), and cheating ($F_{(6,99)}$=2.986, p=0.01). Working memory was a significant predictor for all variables of reciprocity and cooperativeness was a significant predictor of deception in mixed story. The third step adding the ToM items was significant and increased R^2 for cooperation ($F_{(9,96)}$=2.872, p=0.007), deception ($F_{(9,96)}$=13.21, p<0.001), deception in deception story ($F_{(9,96)}$=7.134, p<0.001), and cheating ($F_{(9,96)}$=5.28, p<0.001). Second order true belief was a predictor of cooperation, whereas third order false belief was a predictor of deception, deception in deception story and cheating.

For older adults the first step of the hierarchical regression revealed that once again none of the models were significant. Adding the cognitive measure in the second step generated strong predictors for the model. The analysis uncovered that reasoning was a significant predictor of cooperation and cooperation in mixed story, while working memory was a significant predictor of deception and deception in deception story in older adults. Both cognitive measures significantly predicted deception in mixed story. In the third step adding the ToM measures to the model determined that true beliefs were a predictor of cooperation and false beliefs a predictor of deception. Therefore, older adults with a higher level of true belief of 1st and 2nd order reasoning were better at detecting cooperation, while a higher level of false belief of second and third order reasoning in older adults leads to a higher level of deception and cheating detection. Table 13 reports a schematic synthesis of the predictors of the different reciprocity dimensions in the three age groups.

Table 10: Hierarchical linear regression analysis in the young adult group

	Cooperation			**Cooperation in cooperation story**			**Cooperation in mixed story**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Agreeableness									
Cordiality	0.022	0.024	0.118	0.008	0.017	0.058	0.015	0.014	0.136
Cooperativeness	-0.051	0.037	-0.217	-0.013	0.026	-0.079	-0.038	0.021	-0.282^{+}
Empathic concern	0.084	0.046	0.265^{+}	0.047	0.032	0.216	0.036	0.026	0.201
Altruism	-0.004	0.065	-0.011	-0.014	0.045	-0.049	0.009	0.037	0.041
Step 2									
Working memory	0.226	0.097	0.235*	0.034	0.071	0.051	0.192	0.053	0.158***
Reasoning	0.040	0.036	0.117	0.009	0.026	0.038	0.031	0.020	0.346
Agreeableness									
Cordiality	0.010	0.024	0.054	0.005	0.018	0.040	0.005	0.014	0.046
Cooperativeness	-0.049	0.036	-0.209	-0.013	0.026	-0.079	-0.036	0.020	-0.268^{+}
Empathic concern	0.107	0.046	0.340*	0.051	0.033	0.234	0.056	0.025	0.308*
Altruism	-0.015	0.064	-0.037	-0.015	0.046	-0.053	0.00004	0.035	0.0002
Step 3									
Working memory	0.185	0.097	0.193^{+}	0.003	0.071	0.004	0.183	0.055	0.330
Reasoning	0.066	0.037	0.191	0.028	0.027	0.116	0.038	0.021	0.192
Agreeableness									

Cordiality	0.016	0.024	0.086	0.009	0.018	0.071	0.007	0.014	0.062
Cooperativeness	-0.051	0.036	-0.217	-0.013	0.026	-0.080	-0.038	0.020	-0.281
Empathic concern	0.117	0.045	0.373^{+}	0.058	0.033	0.266	0.059	0.025	0.327
Altruism	-0.027	0.063	-0.067	-0.023	0.046	-0.081	-0.004	0.035	-0.018
TB 1st order	0.193	0.139	0.140	0.183	0.101	0.191	0.010	0.078	0.012
TB 2nd order	0.379	0.201	0.194	0.244	0.146	0.180	0.135	0.113	0.121

R^2	R^2= 0.013 for step 1	R^2= -0.012 for step 1	R^2= -0.007 for step 1
	∂R^2=0.068* for step 2	∂R^2=0.004 for step 2	∂R^2=0.0007*** for step 2
	∂R^2=0.047+ for step 3	∂R^2=-0.003 for step 3	∂R^2=-0.013 for step 3

	Deception			**Deception in deception story**			**Deception in mixed story**			**Cheating**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1												
Agreeableness												
Cordiality	-0.039	0.026	-0.189	-0.021	0.023	-0.120	0.002	0.010	0.027	-0.021	0.016	-0.170
Cooperativeness	-0.033	0.040	-0.130	-0.022	0.035	-0.100	-0.008	0.014	-0.086	-0.023	0.024	-0.147
Empathic concern	0.075	0.050	-0.219	0.088	0.043	0.296	-0.014	0.018	-0.119	0.033	0.030	0.157
Altruism	0.008	0.070	0.018	-0.046	0.061	-0.121	0.005	0.025	0.030	0.048	0.043	0.179
Step 2												
Working memory	0.393	0.101	0.374***	0.233	0.091	0.257*	-0.051	0.039	-0.137	0.162	0.064	0.253*
Reasoning	-0.029	0.037	-0.078	0.020	0.034	0.062	-0.006	0.014	-0.044	-0.022	0.024	-0.098

Agreeableness												
Cordiality	-0.044	0.025	-0.216^{+}	-0.030	0.023	-0.171	0.004	0.010	0.057	-0.022	0.016	-0.175
Cooperativeness	-0.019	0.038	-0.072	-0.018	0.034	-0.060	-0.009	0.015	-0.095	-0.016	0.024	-0.100
Empathic concern	0.101	0.048	0.294*	0.109	0.043	0.367*	-0.019	0.018	-0.158	0.042	0.030	0.201
Altruism	-0.026	0.066	-0.059	-0.060	0.060	-0.158	0.007	0.026	0.048	0.032	0.042	0.121
Step 3												
Working memory	0.231	0.098	0.220*	0.076	0.084	0.084	-0.029	0.043	-0.079	0.084	0.066	0.132
Reasoning	-0.057	0.034	-0.153	-0.010	0.029	-0.032	-0.007	0.015	-0.049	-0.027	0.023	-0.119
Agreeableness												
Cordiality	-0.031	0.023	-0.150	-0.016	0.019	-0.093	0.003	0.010	0.043	-0.018	0.015	-0.145
Cooperativeness	-0.017	0.033	-0.064	-0.016	0.029	-0.070	-0.008	0.015	-0.086	0.014	0.023	-0.092
Empathic concern	0.047	0.043	0.135	0.054	0.037	0.180	-0.014	0.019	-0.118	0.029	0.030	0.137
Altruism	0.021	0.059	0.048	-0.012	0.051	-0.032	0.003	0.026	0.021	0.043	0.040	0.163
FB 1st order	-0.011	0.113	-0.009	0.020	0.097	0.018	0.008	0.050	0.017	-0.175	0.077	-0.228*
FB belief 2nd order	0.226	0.133	0.182	0.237	0.114	0.222*	0.034	0.059	0.078	0.120	0.090	0.160
FB 3rd order	0.441	0.138	0.364**	0.424	0.119	0.404***	-0.073	0.061	-0.171	0.191	0.094	0.259*
R^2	R^2= 0.02 for step 1			R^2= 0.02 for step 1			R^2= -0.02 for step 1			R^2= 0.02 for step 1		
	∂R^2=0.14*** for step 2			∂R^2=0.07** for step 2			∂R^2=0.02 for step 2			∂R^2=0.14* for step 2		
	∂R^2=0.20*** for step 3			∂R^2=0.28*** for step 3			∂R^2=0.02 for step			∂R^2=0.20** for step		

Note. $^{***}p$<.001, $^{**}p$<.01, $^{*}p$<0.05, ^{+}p<.07; FB = false belief; TB = true belief;

Education was registered in years of education; Reasoning was examined with the Raven's Progressive Matrices; Working memory was assessed by the backward digits span; Agreeableness was examined through the agreeableness scale of the Big Five questionnaire; Empathic concern was tested through the empathic concern scale of the Interpersonal reactivity index; Altruism was examined with the Elderly Care Research Center (ECRC) altruistic scale.

Table 11: Hierarchical linear regression analysis for the middle-aged adult group

	Cooperation			**Cooperation in cooperation story**			**Cooperation in mixed story**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Agreeableness									
Cordiality	0.022	0.024	0.105	0.004	0.017	0.030	0.018	0.014	0.153
Cooperativeness	-0.013	0.029	-0.060	-0.004	0.020	-0.029	-0.009	0.016	-0.072
Empathic concern	-0.039	0.033	-0.142	-0.020	0.023	-0.108	-0.19	0.019	-0.122
Altruism	-0.036	0.050	0.090	0.021	0.034	0.078	0.015	0.028	0.068
Step 2									
Working memory	0.332	0.099	0.334**	0.194	0.068	0.289	0.137	0.056	0.248
Reasoning	-0.016	0.023	-0.068	-0.029	0.016	-0.179	0.013	0.013	0.096
Agreeableness									
Cordiality	0.014	0.024	0.070	0.003	0.016	0.020	0.012	0.013	0.101
Cooperativeness	0.0003	0.028	0.002	0.005	0.019	0.032	-0.005	0.016	-0.037
Empathic concern	-0.019	0.033	-0.068	-0.011	0.022	-0.056	-0.008	0.019	-0.54
Altruism	0.029	0.048	0.073	0.016	0.033	0.061	0.013	0.027	0.058
Step 3									
Working memory	0.264	0.108	0.266*	0.139	0.074	0.207	0.125	0.062	0.227
Reasoning	-0.012	0.023	-0.049	-0.025	0.016	-0.152	0.013	0.014	0.096
Agreeableness									

Cordiality	0.022	0.023	0.104	0.007	0.016	0051	0.015	0.013	0.126
Cooperativeness	0.007	0.028	0.032	-0.010	0.019	0.066	-0.003	0.016	-0.024
Empathic concern	-0.032	0.032	-0.114	-0.019	0.022	-0.102	-0.013	0.019	-0.081
Altruism	0.022	0.047	0.056	0.011	0.032	0.040	0.011	0.027	0.052
TB 1st order	0.011	0.129	0.009	0.046	0.089	0.057	-0.035	0.074	-0.053
TB 2nd order	0.609	0.226	0.270**	0.364	0.156	0.238	0.245	0.130	0.195
R^2	R^2= -0.01 for step 1			R^2=- 0.03 for step 1			R^2=- 0.009 for step 1		
	∂R^2=0.10** for step 2			∂R^2=0.09+ for step 2			∂R^2=0.07+ for step 2		
	∂R^2=0.08* for step 3			∂R^2=-0.0004 for step 3			∂R^2=0.03 for step		

	Deception			**Deception in deception story**			**Deception in mixed story**			**Cheating**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1												
Agreeableness												
Cordiality	0.018	0.029	0.070	-0.003	0.022	-0.014	0.007	0.010	0.081	-0.025	0.018	-0.167
Cooperativeness	-0.067	0.034	-0.248	-0.011	0.026	-0.054	-0.036	0.012	-0.370	0.011	0.021	0.064
Empathic concern	-0.042	0.040	-0.126	-0.019	0.030	-0.078	-0.005	0.014	-0.042	-0.023	0.025	-0.113
Altruism	0.070	0.060	0.145	0.035	0.045	0.099	0.008	0.021	0.043	0.029	0.037	0.100
Step 2												
Working memory	0.707	0.101	0.590***	0.323	0.086	0.368***	0.187	0.039	0.430**	0.273	0.072	0.374***
Reasoning	-0.006	0.024	-0.021	0.030	0.020	0.139	-0.025	0.009	-0.236***	-0.006	0.017	-0.032

Agreeableness												
Cordiality	-0.002	0.024	-0.010	-0.017	0.020	-0.092	0.006	0.009	0.061	-0.033	0.017	-0.022^{+}
Cooperativeness	-0.040	0.029	-0.147	-0.0001	0.024	-0.0007	-0.028	0.011	-0.281*	0.021	0.020	0.130
Empathic concern	0.005	0.033	0.014	0.006	0.028	0.024	0.005	0.013	0.039	-0.005	0.024	-0.026
Altruism	0.056	0.049	0.117	0.029	0.042	0.084	0.003	0.019	0.019	0.024	0.035	0.082
Step 3												
Working memory	0.518	0.093	0.432***	0.169	0.079	0.192*	0.184	0.041	0.423	0.166	0.069	0.228*
Reasoning	-0.020	0.021	-0.070	0.013	0.018	0.060	-0.022	0.009	-0.209	-0.010	0.016	-0.055
Agreeableness												
Cordiality	0.030	0.022	0.118	0.016	0.019	0.088	0.002	0.010	0.023	-0.019	0.016	-0.125
Cooperativeness	-0.051	0.026	-0.189^{+}	-0.019	0.022	-0.096	-0.022	0.011	-0.023	0.022	0.019	0.136
Empathic concern	0.018	0.029	0.052	0.017	0.025	0.069	0.005	0.013	0.037	0.0008	0.022	0.004
Altruism	0.012	0.043	0.025	-0.005	0.037	-0.014	0.002	0.019	0.009	-0.004	0.032	-0.014
FB 1st order	-0.045	0.100	-0.033	0.011	0.085	0.108	-0.083	0.045	-0.169	-0.130	0.074	-0.158
FB 2nd order	0.164	0.100	0.127	0.093	0.085	0.099	0.023	0.045	0.049	0.092	0.074	0.118
FB 3rd order	0.461	0.090	0.405***	0.395	0.077	0.474***	-0.003	0.040	-0.007	0.267	0.067	0.386***
R^2	R^2= 0.02 for step 1			R^2= -0.03 for step 1			R^2= 0.08** for step 1			R^2= -0.01 for step 1		
	∂R^2=0.31*** for step 2			∂R^2=0.158*** for step 2			∂R^2=0.19*** for step 2			∂R^2=0.31*** for step 2		
	∂R^2=0.18*** for step 3			∂R^2=0.23*** for step 3			∂R^2=0.02 for step			∂R^2=0.18*** for step		

Note. $^{***}p$<.001, $^{**}p$<.01, $^{*}p$<0.05, ^{+}p<.07; TB = true belief, FB = false belief;

Education was registered in years of education; Reasoning was examined with the Raven's Progressive Matrices; Working memory was assessed by the backward digits span; Agreeableness was examined through the agreeableness scale of the Big Five questionnaire; Empathic concern was tested through the empathic concern scale of the Interpersonal reactivity index; Altruism was examined with the Elderly Care Research Center (ECRC) altruistic scale.

Table 12 : Hierarchical linear regression analysis in the older adult group.

	Cooperation			**Cooperation in cooperation story**			**Cooperation in mixed story**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Agreeableness									
Cordiality	0.056	0.033	0.220^{+}	0.033	0.020	0.220	0.023	0.020	0.142
Cooperativeness	0.037	0.037	0.128	-0.011	0.022	-0.065	0.048	0.023	0.265
Empathic concern	-0.009	0.043	-0.021	-0.013	0.026	-0.053	0.004	0.027	0.018
Altruism	-0.027	0.064	-0.053	0.044	0.038	0.147	-0.071	0.040	-0.223
Step 2									
Working memory	0.135	0.125	0.118	0.081	0.079	0.046	0.055	0.074	0.076
Reasoning	0.053	0.019	0.305**	0.005	0.011	0.189	0.048	0.011	0.442***
Agreeableness									
Cordiality	0.043	0.031	0.167	0.029	0.020	0.189	0.014	0.018	0.086
Cooperativeness	0.009	0.036	0.031	-0.014	0.023	-0.081	0.023	0.021	0.125
Empathic concern	0.015	0.043	0.036	-0.003	0.027	-0.013	0.018	0.025	0.070
Altruism	-0.003	0.061	-0.005	0.049	0.039	0.164	-0.052	0.036	-0.164
Step 3									
Working memory	0.018	0.116	0.015	0.016	0.012	0.003	0.002	0.071	0.003
Reasoning	0.040	0.017	0.231*	-0.0003	0.078	0.372***	0.041	0.010	0.372***
Agreeableness									

Cordiality	0.021	0.028	0.083	0.018	0.019	0.019	0.003	0.017	0.019
Cooperativeness	0.004	0.032	0.017	-0.015	0.022	0.109	0.020	0.020	0.109
Empathic concern	0.018	0.038	0.045	-0.001	0.025	0.076	0.019	0.023	0.076
Altruism	-0.0001	0.054	-0.0002	0.051	0.036	-0.162	-0.051	0.033	-0.162
TB 1st order	0.392	0.152	0.236*	0.230	0.102	0.155	0.162	0.093	0.155
TB 2nd order	0.625	0.168	0.340***	0.262	0.113	0.314***	0.363	0.102	0.314***
R^2	R^2= 0.04+ for step 1			R^2= 0.03 for step 1			R^2= 0.03 for step 1		
	∂R^2=0.12*** for step 2			∂R^2=0.21*** for step 2			∂R^2=0.21*** for step 2		
	∂R^2=0.19*** for step 3			∂R^2=-0.13*** for step 3			∂R^2=-0.13*** for step 3		

	Deception			**Deception in deception story**			**Deception in mixed story**			**Cheating**		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1												
Agreeableness												
Cordiality	0.058	0.036	0.205	0.025	0.026	0.044	0.003	0.015	0.029	0.018	0.023	0.104
Cooperativeness	-0.031	0.041	-0.096	-0.013	0.030	-0.078	0.011	0.017	0.090	0.037	0.026	0.187
Empathic concern	-0.107	0.048	-0.242	-0.033	0.035	0.003	-0.028	0.019	-0.163	-0.016	0.030	-0.057
Altruism	0.058	0.071	0.104	0.068	0.052	0.211	0.002	0.029	0.007	-0.038	0.045	-0.111
Step 2												
Working memory	0.672	0.125	0.532***	0.301	0.102	0.332**	0.135	0.008	0.273*	0.164	0.084	0.210+
Reasoning	0.012	0.019	0.062	0.007	0.015	0.052	0.016	0.055	0.213+	0.038	0.013	0.319**

Agreeableness												
Cordiality	0.022	0.031	0.078	0.009	0.025	0.044	-0.006	0.014	-0.052	0.005	0.021	0.028
Cooperativeness	-0.038	0.036	-0.121	-0.018	0.030	-0.078	0.003	0.016	0.021	0.017	0.024	0.085
Empathic concern	-0.032	0.042	-0.071	0.001	0.034	0.003	-0.011	0.019	-0.063	0.008	0.029	0.030
Altruism	0.092	0.061	0.165	0.084	0.049	0.211^{+}	0.013	0.027	0.060	-0.018	0.041	-0.052
Step 3												
Working memory	0.540	0.110	0.427^{***}	0.238	0.092	0.263	0.096	0.055	0.194^{+}	0.099	0.081	0.126
Reasoning	-0.021	0.018	-0.107	-0.026	0.015	-0.189	0.012	0.009	0.163	0.019	0.013	0.158
Agreeableness												
Cordiality	0.030	0.027	0.104	0.019	0.022	0.092	-0.004	0.013	-0.034	0.006	0.020	0.031
Cooperativeness	-0.040	0.031	-0.126	-0.025	0.026	-0.109	0.004	0.015	0.036	0.014	0.023	0.070
Empathic concern	-0.021	0.037	-0.047	-0.001	0.031	-0.004	-0.008	0.018	-0.045	0.018	0.027	0.066
Altruism	0.005	0.053	0.010	0.027	0.044	0.068	-0.008	0.027	-0.036	-0.063	0.039	-0.182
FB 1st order	-0.059	0.120	-0.040	0.105	0.100	0.098	-0.028	0.060	-0.048	-0.083	0.088	-0.089
FB 2nd order	0.238	0.092	0.245^{*}	0.210	0.077	0.301^{**}	0.003	0.046	0.009	0.216	0.068	0.358^{**}
FB 3rd order	0.423	0.095	0.368^{***}	0.275	0.080	0.333^{***}	0.147	0.048	0.325^{**}	0.120	0.070	0.168^{+}
R^2	R^2= 0.03 for step 1			R^2= 0.003 for step 1			R^2= -0.01 for step 1			R^2= 0.007 for step 1		
	$\partial R^2=0.28^{***}$ for step 2			$\partial R^2=0.113^{***}$ for step 2			$\partial R^2=0.15^{***}$ for step 2			$\partial R^2=0.28^{***}$ for step 2		
	$\partial R^2=0.20^{***}$ for step 3			$\partial R^2=0.23^{***}$ for step 3			$\partial R^2=0.09^{*}$ for step			$\partial R^2=0.20^{***}$ for step		

Note. $^{***}p<.001$, $^{**}p<.01$, $^{*}p<0.05$, $^{+}p<.07$; TB = true belief; FB = false belief;

Education was registered in years of education; Reasoning was examined with the Raven's Progressive Matrices; Working memory was assessed by the backward digits span; Agreeableness was examined through the agreeableness scale of the Big Five questionnaire; Empathic concern was tested through the empathic concern scale of the Interpersonal reactivity index; Altruism was examined with the Elderly Care Research Center (ECRC) altruistic scale.

Table 13: Summary of the significant and marginally significant predictors of the different reciprocity dimensions for each age group

	Cooperation	Deception	Cheating
Young adults	Working memory (marginal, p=0.0596) Empathic concern	Working memory Third-order false belief	First-order false belief Third-order false belief
Middle-aged adults	Working memory Second-order True belief	Working memory Cooperativeness (marginal, p=0.0504) Third-order false belief	Working memory Third-order false belief
Older adults	Reasoning First-order true belief Second-order true belief	Working memory Second-order false belief Third-order false belief	Second-order false belief Third-order false belief

5. DISCUSSION

The present study first aimed at investigating age-related differences in the detection of the different components of reciprocity: deception, cheating, and cooperation. With this aim in mind, we used a task assessing various reciprocity items through stories with a cooperative, deceptive, and mix of both, contexts including Theory of Mind (ToM) items. Second, it intended to examine the predictors of reciprocity, such as cognitive measures, personality dispositions (namely, the cooperativeness and cordiality dimensions of agreeableness, altruism, and empathic concern), and true and false beliefs.

Regarding the first aim, the results showed that younger and middle-aged adults were better at detecting cooperation, especially, in cooperation stories, deception in both deception and mixed stories, and cheating in comparison to older adults, controlling all outcomes for the years of education, which is in line with our expectations. These results indicate that the decline in the detection of the reciprocity components starts at 65 years old. These findings are consistent with previous results of Calso and colleagues (2019b) as well as Raimo et al. (2022) on reciprocity. However, it is important to note that Calso and colleagues (2019b) only considered scores depending on the type of story, therefore making no distinction between the reciprocity items and ToM items, as well as a total score of the task, whereas Raimo et al. (2022) only analyzed the total score, regrouping all the subcomponents.

Hence, the novelty of these results lies in the analysis of the reciprocity and deception subscales by type of story. De facto, we found different age patterns. Younger adults were significantly better at detecting deception in deception stories, whereas middle-aged adults were better at detecting deception in mixed stories compared to older adults. Both younger and middle-aged adults were better at detecting cooperation in cooperation stories in comparison to older adults. We expected to find different age-related differences for the various types of stories, but surprisingly and contradictory to what we hypothesized age differences in the mixed

stories were only found in deception and not in cooperation. This may be interpreted by the difficulty of the task. Indeed, we found that performance scores in deception were lower compared to cooperation.

Concerning the second aim, reciprocity, deception, and cheating detection, appeared to be predicted by the cognitive measures of working memory and reasoning, the personality dispositions of empathic concern and cooperativeness, and true or false beliefs depending on the age groups as expected.

Younger adults' working memory was predictive of their capacity to detect cooperation and deception, even if marginally, but not cheating. For the middle-aged group only working memory was a cognitive predictor of the different reciprocity dimensions, e.g., cooperation, deception, and cheating. Alternatively, older adults used distinct cognitive abilities for different reciprocity dimensions. For this group working memory revealed to be a strong predictor for the detection of deception, while reasoning was a predictor for the detection of cooperation. The distinctive use of cognitive resources between cooperation and detection as found in the literature (Lissek, 2008; Phillips et al., 2011; Stewart et al., 2018) was only observed in older adults, contrary to our expectations.

In line with our hypothesis, the personality dispositions played a predictive role in the younger adult group and faded throughout the age groups. For younger adults, empathic concern was a positive predictor of cooperation detection in the final equation of the regression. These results could be explained by a feeling of compassion that arises in younger adults for elder people, activated by the task since empathic concern is characterized by feelings of warmth and compassion for others experiencing negative situations or a feeling of protection towards people that can be taken advantage of. For example, in mixed stories, two characters collaborate to deceive a third character for which a feeling of compassion can emerge. Therefore, people with a higher empathic concern would be more prone to detect this

collaborative scheming due to their compassion for the victim. Middle-aged adults showed a nearly significant and negative predictive role of agreeableness in the detection of deception, but no other personality dispositions were significant. This correlation is consistent with the literature on economic games (Sabater-Grande et al., 2022) and self-report reciprocity questionnaires (Perugini, 2003) where agreeableness correlated positively to positive reciprocal behavior and negatively to negative reciprocal behavior. Agreeableness is considered the central personality disposition to be involved in maintaining social interactions and engagement (Baek et al., 2016). Thus, middle-aged adults with a higher level of cooperativeness, one of the dimensions of agreeableness, have trouble detecting negative reciprocity. For older adults, no personality dispositions were predictors of cooperation, deception, and cheating at the last step of the regression.

Lastly, true belief did predict cooperation in all stories, while false belief was a predictor of deception in all stories, both for all age groups. Above all else, understanding true and false beliefs showed to be the dominant predictor in all age categories for all reciprocity dimensions. The predictive role of true and false beliefs was only marginal in younger adults and became significant in the middle-aged and older adult groups. These results are in line with the findings of Lissek and colleagues (2008) on the association between belief reasoning and cooperation and deception detection. Interestingly the prediction grew strong with age since in the older adult group first and second-order true belief significantly predicted cooperation and not only third-order false belief but also second-order false belief predicted deception, deception in deception story, and cheating.

As hypothesized reciprocity dimensions are predicted by personality dimensions, cognitive abilities, and theory of mind competences. However, the reciprocity dimensions are explained by different variables across age groups. Cognitive measures and ToM abilities are relevant predictors of reciprocity in all age group. Cooperation and deception are predicted both

by cognitive measures and ToM abilities for all age groups, while cheating is only predicted by ToM abilities in younger and older adults and by working memory in middle aged adults. It is interesting to note that the predictive role of personality dispositions is important at a young age but fades when we get older.

A limit of this study is the observational stance of the task we used. It would maybe be more appropriate to evaluate reciprocity and its dimensions with a more ecological and interactive task. Another limitation of our study could be the fact that the reciprocity detection task was solely visual while older adults have shown more difficulties in detecting visual modalities of deception rather than audio and audiovisual modalities (Sun et al., 2020). In the future, it could be very useful to add other modalities to verify if the decline in reciprocity could be related to the modality or is indeed a decline of the reciprocity dimensions.

To conclude, using the different subscales and types of stories of the task allowed us to make a clear distinction between cooperation, deception, and cheating demonstrating the different predictive roles of cognition, personality dispositions and ToM abilities in a precise context and age group. It could therefore be interesting for future studies to maintain these distinctions in coding. Moreover, this study uncovered that the decline in the detection of reciprocity dimensions occur in older age, specifically starting from 65 years old, by providing a continuum of three age categories. Importantly, this specific regression analysis, acknowledging the ties between beliefs and reciprocity, supports Calso's approach of using a ToM task to evaluate deception and confirms that cognition and social cognition are important concepts to detect reciprocity. Further studies should continue investigating this topic regrouping the reciprocity dimensions through various contexts using a naturalistic task.

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Chapter VII. Study 4 - An interactive approach showing the association between social functioning and theory of mind in aging.

1. ABSTRACT

Social interactions are known to diminish with aging. Some studies report that it could be due to a decline in social cognition as well as a decline in social functioning. Other studies have linked social functioning to social cognition, although, they examined social functioning through self-report questionnaires or assessed the ability to detect social functioning. No studies have yet researched the age-related differences in performance of reciprocal behavior. Therefore, the objective of this study was to consider the possible age-related differences in reciprocal behavior and the eventual predictive effect of Theory of Mind (ToM) and cognition on this decline, along with an association between cognition, ToM and reciprocal behavior in the different age groups. For this purpose, we collected a sample of 56 younger adults and 56 older adults, to whom we administered a second-person interactive and ecological reciprocity task, the interactive drawing task (IDT), in addition to some cognitive measures and ToM tasks. Overall, older adults evidenced a lower physical, collaborative, and flexible reciprocal behavior in comparison to the younger adult group. This age-related decrease was linked to the decline in cognitive abilities but not ToM. On the other hand, older adults manifested a predictive effect of ToM on physical, collaborative, and flexible reciprocity. This effect shows that the ability for older adults to contextually infer mental states is associated to their ability to contribute to the drawing appropriately and collectively, and to adapt their contributions to the intentions of the experimenter. First and foremost, adopting such an approach has proven to be useful to investigate older adults' reciprocal behavior. Second and last, the study demonstrated that reciprocal behavior relies on the ability to infer the other's mental states.

Keywords: reciprocity, aging, Theory of Mind, second-person perspective, interactive

2. INTRODUCTION

Throughout the lifespan, the number and quality of social interactions can diminish for cognitive, neural, perceptual, and motivational reasons (Henry et al., 2023). At the same time, Human beings are social by nature and need to belong. Consequently, the literature has extensively researched social interactions and proven that a socially active lifestyle helps to maintain cognitive capacities, which lead to a better quality of life (Boggatz, 2016; Miceli et al., 2018). Thus, social functioning is crucial in healthy ageing. However, few studies (Bailey et al., 2008) investigate the underlying predictors of it.

Social functioning is defined as an individual's ability to relevantly participate, organize, and preserve collective everyday interactions and reciprocal relationships with others to have a successful social life (Bottema-Beutel et al., 2019; Hirschfeld et al., 2000). It measures our capacity to adapt and fit to a social environment (Bosc, 2000).

Additionally, Gallotti and colleagues (2017) proposed a model where social interaction is viewed as referring to information exchange rather than simply sharing goals in joint action. For them, the level of reciprocity and mutual adaptation should define social interactions. They even define reciprocity as a sort of mutual alignment that creates adjustments in both parties of the exchange. Consequently, a core element of social functioning is reciprocity.

Voelkl (2015) introduces reciprocation as "a reactive strategy where individuals condition their behavior on the previous behavior of their interaction partner" (p.17). Moreover, the literature makes a distinction between generalized, direct, and indirect reciprocity. Generalized reciprocity is about the overall social interactions an individual had in the past. Individuals will behave towards others in the same way others behave towards them (Sun et al., 2020). Direct reciprocity is based on the ongoing interaction between two protagonists (Schmid et al., 2021), whereas indirect reciprocity is based on reputation, it is a continuous evaluation of each other's behavior by the entire population. Overall, reciprocity emerges in a shared

interaction (Wörle & Paulus, 2019). Indeed, several social interactions require reciprocity, such as conversations where you alternatively speak and listen. Therefore, the study will focus on direct reciprocity in social interactions between individuals.

In ageing a few articles investigated the role of perceived reciprocity in social exchange (Braun et al., 2018; Wahrendorf et al., 2010) rather than the concept itself. Nevertheless, Braun and colleagues discovered an age-related difference and decline in perceived reciprocity over time. In addition, they determined that the importance of perceived reciprocity varies with the type of relationship, i.e., spousal (partner), communal (children, grandchildren, close friends) and exchange (colleagues, neighbors) relationships. These findings are consistent with the socioemotional selective theory, which states that social motives and emotional goals change throughout the lifespan (Cartensen et al., 2003). Older adults choose to reduce social contacts to maintain connections with family and close ones. This decrease in social interaction could be a factor of a decline in social cognition, especially in unfamiliar contexts, according to Ferguson and Bradford (2021). Evans et al. (2018) established that social isolation is negatively correlated to cognitive functions, but the relationship between social functioning and social cognition is yet to prove.

Even though, Bailey et al. (2008) mention that a bidirectional relationship between social functioning and cognitive empathy could exist, studies tend to focus more on the impact of declining social cognitive abilities on social functioning than the other way around. For instance, Fett et al. (2014) demonstrated that a high capacity to take others' perspectives into account was associated with a greater prosocial approach in adolescents. Furthermore, several studies in children (Shug et al., 2016; Zhang et al., 2019) and adults (Sun et al., 2020) found that understanding others' intentions impacted reciprocal behavior, which presumes that ToM influences reciprocity. By definition, ToM requires the ability to attribute mental states to others which is crucial to understand others' intentions. Besides, Shug et al. (2016) found that ToM

abilities affect positive but not negative reciprocity in pre-school children. Not to mention that Sun et al. (2020) detected a major role of human intentions on generalized reciprocal behavior where adults showed an improved reciprocal behavior in intentional rather than unintentional exchanges.

On the other hand, only some articles studied the influence of social functioning on cognitive abilities in the literature on ageing. Notably, Calso and colleagues (2019a, 2019b) found an age-related difference in the ability to detect reciprocity through a mentalizing task (the aforementioned MPS-TOMQ taks) and a positive correlation between this ability and some frontal executive processes, i.e., flexibility. Our study on reciprocity detection also determined that older adults had a greater difficulty to detect reciprocity compared to younger and middle-aged adults, and that their cognitive abilities (i.e. reasoning, working memory) as well as their understanding of true and false beliefs predicted their detection of the different reciprocity dimensions (deception and cooperation). But even though this task assessed performance, the issue is that it was measured in an observational stance, which could affect older adult's motivation to use their resources even more. According to Henry and colleagues (2023), the controlled lab environment of many tasks could influence the motivation of older adults for cognitive demanding tasks with no personal meaning or direct social impact and exacerbate the age gap in performance.

This "lab" and "real life" dilemma was mentioned previously in our meta-analysis, which determined that over ninety percent of the ToM tasks found in the literature on age-related differences are studied in social observation. However, several authors (Ferguson & Bradford, 2021; Moore & Baresi, 2017; Redcay & Schilbach, 2019) stress the importance of reciprocal interaction. Moore and Barresi (2017) underlined reciprocity as one of the five forms of information useful to interaction, also called second-person information, among self-directedness, contingency, affective engagement, and shared intentional relations. Nevertheless,

lab tasks (Calso et al., 2019a; Calso et al., 2019b) or self-report questionnaires (Braun et al., 2018; Wahrendorf et al., 2010) are usually used to evaluate reciprocity in aging. The interactive part of social interaction is absent to mimic a real-life social context. For this reason, we decided to use a second-person interactive task where the participant would be asked to react several times to immediate actions of the experimenter.

Due to the lack of investigation of social functioning, particularly reciprocity, in aging this study aims to investigate the age-related differences in direct reciprocity by using an interactive ecological task. According to the socioemotional selective theory and the results of Braun and colleagues (2018) and Calso et al. (2019a, 2019b), we assume that the young participants will show more reciprocity than the older adults. Furthermore, Alkire et al. (2018) demonstrated that social interaction activates mentalizing processes even if not needed. Besides, the cognitive reserve theory emphasizes that cognitive function is stimulated by the complexity of social interactions (Bennett et al. 2006). Therefore, this paper will also examine if age-related differences in ToM and cognitive functioning partially explain age-related differences in direct reciprocity. In view of the association between perspective-taking and prosocial behaviour found in adolescence (Fett et al. 2014), an association between positive reciprocity and false belief in children (Schug et al., 2016), along with our findings on a predictive effect of ToM on reciprocity detection, our study will test the association between diverse ToM tasks and reciprocal behavior. We predict that ToM capacities will be a significant predictor of reciprocity in the older adult sample like in our previous study.

3. METHOD

3.1. Participants

A sample of 130 Italian participants from Lombardy and Abruzzo were tested for the study. A power analysis was conducted ad hoc to the study, which revealed that 128 participants were sufficient to discover an effect size of 0.5 in an independent t-test with statistical power at

0.80 and α with two tails at .05. After sorting the data, a total sample of 116 Italian adults remained. The sample was divided into two age groups, namely, 58 younger adults (22 women, age range: 18-31, M=23.93, SD=3.4) and 58 healthy older adults (42 women, age-range: 64-91, M=75.43, SD=6.65) still involved in their community. All participants were volunteers and found through flyers, word-of-mouth, and students in different social activity clubs and at the university.

The two groups showed a significant difference in years of education ($F_{(1, 114)}$= 64.01, p < 0.001). Our sample of younger adults studied for a longer period (M_{young}=15.31 years, SD_{young}=2.19) compared to the older adults (M_{old}=10.79 years, SD_{old}=3.7).

To select a healthy aging sample, a control for dementia signs was completed through the Mini-Mental State Examination (MMSE, Folstein et al., 1975) on the older adults group. Those with an MMSE lower than 23.9 were excluded from the study (M=27.11, SD=1.5).

3.1. Demographic questionnaire

A demographic questionnaire was created ad hoc for this study. Participants are asked to provide a few personal data, such as age, gender, marital status, years of education, highest degree obtained, and actual and former profession. They are also asked to evaluate their physical condition at the time and in 10 years from that moment (from very good to bad), as well as if they have any neurological pathologies, are taking any medication that could alter their attention span and have any familiarity with computers.

3.2. Executive functions tests

A. Trail making Task (TMT) A-B

The TMT was created by Reitan (1958) aiming to examine the shifting ability of the executive functions. It is a pencil and paper task that only includes numbers from 1 to 25, in part A and both numbers and letters in part B, the numbers go from 1 to 13, and the letters from A to N. In this case, only the letters of the Italian Alphabet were included, thus the j was

excluded. In part A, the participants are asked to connect the numbers in ascending order through a line (e.g. 1-2-3), whereas, in part B the participants were asked to connect numbers and letters alternatively (e.g. 1-A-2-B). For part B, subjects are instructed to start with a number by a written directive above the exercise. Before starting the test, an example version is resolved with the participants to make sure the instructions are clear. The participants are timed for both parts separately. The time difference between parts B and A gives us the shifting reaction time.

B. The Stroop color and Word test (SCWT)

The SCWT (Caffarra et al., 2002) measures the inhibition of cognitive interferences. Participants receive three different requests, the first two are the so-called "congruent conditions" where no interferences can occur, and the third one is the "incongruent condition" which could create some cognitive interferences. In the congruent condition, participants start by reading the words that represent a color (also called the color-words; e.g. blue) printed in black and white, as quickly as possible. Afterward, they are asked to name the colors of the filled circles, which are presented to them, as fast as possible. Finally, for the "incongruent condition", the participant is presented with color-words, this time printed in a different and conflicting color, but are still asked to read the written color-word as fast as possible, which forces them to inhibit the color of the ink. The interference can thus happen when a participant pronounces the color of the ink instead of the written color-word. Participants are timed for each part, and the number of interferences are reported. The difference between the errors (interferences) of the incongruent condition and the sum of the errors of the congruent conditions divided by two is scored along with the reaction time based on the same equation.

3.3. Reciprocity task and questionnaire

A. Interactive Drawing Task (IDT)

The IDT (Backer van Ommeren et al., 2017) is an implicit interactive second-person task evaluating reciprocal behavior through a drawing. The participant is instructed to draw

together with the experimenter. The purpose is to equally initiate objects to maintain a relevant response to the other's drawing, which results in a high reciprocal behavior. Therefore, the experimenter tries to elicit reciprocal interaction by initiating concepts (reciprocal interaction in the experimenter's initiative), continuing concepts of the participant (reciprocal interaction), and interfering with the objects drawn by the participant (reciprocal flexibility). The experimenter needs to try to maintain a balance between them and the participant in introducing drawing concepts. The first person to give meaning to a drawing by defining it is considered the initiator of the drawing. E.g., drawing a part of a roof on a square tells us that the intention is to draw a house.

The total score is a sum of four different evaluations of the reciprocal behavior.

- Turn-taking: This is a physical assessment of the reciprocal behavior. After each drawing turn, the experimenter pushes and turns the paper back to the participant and analyzes if the participant does the same. If the participant pushes the paper back, one point is granted to him. If he pushes and turns the paper or only turns the page, he scores 2 points. The possible total score depends on the number of drawing turns and ranges between 0 and 2.
- Reciprocal interaction: Every time the participant adds a meaningful object to the drawing not considering who initiated it, he is given one point per drawing turn. The contribution of the participant must be meaningful and coherent with the rest of the contributions aiming at a mutual goal. For example, adding a second character to create a family, adding a garden to a house, etc. The score is then divided by the number of turns and can go between 0 and 1.
- Reciprocal interaction in the experimenter's initiative: This scoring is the continuity of the reciprocal interaction score, which means that if a point is given for reciprocal interaction in the experimenter's initiative there is automatically a point attributed for

reciprocal interaction. The participant is still judged on his willingness to collaborate towards a meaningful drawing but, in this case, adding to an object initiated by the experimenter. For example, the experimenter draws half of a three and the participant draws the other half, or a character is drawn with no details like hands and eyes and the participants add these due details. The score is then divided by the number of turns and can range between 0 and 1.

- Reciprocal flexibility: The participant is judged on his ability to adapt to a meaningful change in the drawing. The experimenter will do this at three separate times. The first changing contribution is called the *interfering contribution*. The experimenter adds an element to an object initiated by the participant, for example, a trailer to a car or swings against a tree. The second change is called an *absurd contribution*. Here, the experimenter will draw two arms and one hand on an object of the participant in an nonsensical place to make it absurd. The third change is the *destructive contribution*, where the experimenter draws a cloud with a lightning bolt touching one of the participant's objects to destroy it, preferably not a living object suc as a character or animal. The changes are defined as accepted by the participant if he collaborates to this change by continuing the drawing. E.g., drawing the second hand for the absurd contribution, coloring the lightning bolt, or adding rain for the destructive contribution. A score of 1/3 is given for each accepted flexibility contribution.

Reciprocal interaction and reciprocal interaction in the experimenter's initiative are considered collaborative reciprocity. We decided to add the measure of reciprocal interaction in the participant's own initiative to be able to distinguish when the participant had to take the other's perspective or continue the drawing they had in mind.

The participant and experimenter draw together for 10 minutes, given that five specific inputs are present in the drawing. The five specific inputs are defined by the drawing of a house, a bow, and the three flexibility contributions. The performance was filmed.

In addition to the task, a self-report questionnaire was given to the participants to evaluate their perception of their reciprocal behavior during the drawing. This questionnaire was created by us to evaluate the perception of the task together with the actual performance. The questionnaire was twofold: the first part was related to their motivation, perception of the task, the perception of closeness, meta-cognitive judgment, emotional state, cooperativeness, (i.e., did they like the task/experimenter; how did they think they performed; did they feel a sense of union with the experimenter; did they feel happy, relaxed). It was evaluated by a 10-point Likert scale, from 1 (= not at all) to 10 (very much). The second part was related to their actual performance of the task. The participant was asked questions on the accuracy, intentionality, and awareness of five predefined moments of the drawing: the first input of the experimenter, the first meaning given by the experimenter, and the three flexibility contributions.

B. Personal Norm of Reciprocity (PNR)

The PNR (Perugini & Gallucci, 2001) is a self-report questionnaire composed of 27 items divided into three components of 9 items each: positive reciprocity, negative reciprocity, and beliefs in reciprocity. For the positive reciprocity subscale, the participants are asked to value how much they resonate with a positive reaction to a positively valued interpersonal behavior of a third person. E.g., “If someone does a favor for me, I am ready to return it”. For the negative one, they must value if they would return a negative valued behavior, for example, “If somebody puts me in a difficult position, I will do the same to him/her”. The beliefs subscale values a more general belief system in the norms concerning both positive and negative reciprocal behavior, e.g., “If I help tourists, I expect that they will thank me nicely”. The item

is valued on a 7-point Likert scale, going from 1 (not true to me) to 7 (very true for me). The score for each subscale goes from 0 to 63.

3.4. Creativity questionnaire

A. Kaufman Domains of Creativity Scale (K-DoCS)

The K-DoCS (Kaufman, 2012) is a self-report questionnaire valuing a person's creative skills compared to their peers. It is composed of five subscales, however, for this study, only the artistic subscale of the K-DoCS was used, containing 9 items. The participants are asked to rate their level of creativity, comparing themselves to their peers, people of the same age and life experience, for each activity proposed. If the items refer to an artistic activity they have never done, the participants are asked to refer to their performance of something similar. They must value each item on a 5-point Likert scale ranging from 1 (much less creative) to 5 (much more creative). The total score can thus vary between 0 and 45.

3.5. Theory of mind (ToM) tasks

A. Mind Picture Story – Theory of Mind Questionnaire (MPS-TOMQ)

The MPS-TOMQ (Calso et al., 2019a) examines the ability to detect deception and cooperation in the context of deception and cooperation, along with ToM performance assessing the ability to understand false and true beliefs with a non-verbal visual setting. It includes six stories: two deception, two cooperation, and two mixed stories. Each story is formed by two pictures. The participant is asked to place four pictures in a meaningful sequence. The correct sequence is then presented to the participant, and questions are asked to see if the participant is able to detect cooperation, deception, cheating and understand true and false beliefs. The questionnaire contains twenty-four items, which can be scored 0 (not correct), 1 (partially correct), and two (completely correct). The score is thus between 0 and 48.

B. Silent Film (SF) task

The SF task (Devine & Hughes, 2013) measures the ability to attribute mental states appropriately to a third party. It consists of five silent video clips taken from the silent comedy of Harold Lloyd, “Safety Last”. The participant is asked one or two questions on the mental states of the characters after viewing a clip. Each answer can be coded 0 (fail, no mention of mental states or misses the point completely), 1 (partial answer use of mental states but not appropriately explained), or 2 (full answer, appropriate interpretation of characters' mental states). The total score can range from 0 to 12.

C. Animation task

The Animation task (Abell et al., 2000) measures the ability to attribute mental states appropriately and understand their intentionality without relying on social cues. It involves silent video clips displaying two animated triangles. The task includes three conditions but, in this study, we only used two of them, namely, the action-oriented condition and the ToM condition. In the action-oriented condition, the movement of the two triangles is only goal-oriented, while in the ToM condition, the movements represent complex and intentional social interactions.

There are four different storylines present in each condition. The participants see eight clips in total. Four were action-oriented, and the other four were ToM clips.

After each clip, the participants are asked to describe what they saw.

Two clips are first shown as examples and detailed with the participants. The order of the clips is partially randomized into four randomization patterns.

The participants' answers are scored in two ways: the appropriateness and the intentionality.

The appropriateness ranges from 0 (no (meaningful) response) to 3 (clear answer, depicting the appropriate actions or mental states).

The intentionality is scored from 0 to 5 and depends on the level of mental states the participant attributes to the triangles and their level of complexity.

D. Director task

The Director Task (Dumontheil et al., 2010) is a computer-based task measuring the ability to take the perspective of a person giving instructions, the so-called director. A sixteen-squared grid containing 8 objects, appears on a screen with the director behind. The participants are instructed to follow the director, asking them to move some objects. They are informed that some grids are closed, and the objects displayed inside are concealed from the director. Before starting the experiment, the participants receive detailed information and have a test run to ensure the clarity of the instructions. The task starts with the director giving instructions to the participants to move objects left, right, up, or down. It comprises 48 trials among which 32 are fillers, 8 are controls, and 8 are experimental. In the experimental trials, a distractor is placed in one of the closed grids. A distractor is an object matching the instruction of the director, for example, a small ball, but that is concealed from the director. For these trials, the participant must take the perspective of the director and move an object corresponding to the instruction not considering the distractor. In the control trials, the distractor is replaced by an irrelevant object. Only the 8 control and 8 experimental trials are scored on accuracy. It was coded 0 if the wrong object (distractor or completely wrong) was moved and 1 if the target object was selected.

3.6. Procedure

The tests were administered in two sessions of roughly an hour and a half each. In the first session, the participants received a small briefing on the data collection and signed a consent form. After the consent form, all participants started with the demographic questionnaire followed by the MMSE (only for older adults), the PNR, the IDT, and ended with the Director task.

For this first encounter, two experimenters were present to ensure the recording of the drawing. The drawing task was performed by the same experimenter with all the participants to maintain a coherency through all the drawings. After asking for the participant's consent, the task was filmed to facilitate the scoring.

For the director task, we almost immediately noticed that older adults had too many difficulties with the mouse. Therefore, the same experimenter used the mouse to move the objects indicated by the participant, which prevented us from using the reaction time of the task.

During the second encounter the MPS-TOMQ, the K-DoCS, the Animation task, The Stroop color and word test, the TMT A-B, and the Silent film task were administered in this order. Only one experimenter was present for this encounter.

The two sessions were separated by one or a maximum of 5 days.

4. RESULTS

4.1. Statistical analysis

First, we wanted to identify age-related differences in the cognitive, reciprocity and ToM variables. Therefore, we ran several one-way analyses of variances (ANOVAs) on the executive functioning variables (shifting and inhibition). Moreover, analysis of co-variances (ANCOVAs) controlling for years of education on a series of ToM components (contextually inferring mental states to movie characters; understanding false beliefs; inferring mental states to animated shapes without social cues; perspective-taking) were conducted. Additionally, for two of the ToM components we also conducted 2X2 repeated measure ANOVAs including, for the Silent Film task, two conditions (ToM and action) as within variables and two age-groups (young or old) as between variable, and for the Director task, two conditions (experimental and control) as within variables and two age-groups (young or old) as between variables. Furthermore, other ANCOVAs controlling for education as well as the confidence and perception of the IDT, were

performed on reciprocity measures (turn taking, reciprocal interaction, reciprocal interaction in the experimenter's initiative, reciprocal interaction in the participant's own initiative, and flexibility).

Second, we computed hierarchical linear regression analyses on the entire sample including the variables in which age-differences were found, to identify which ones explain and predict the age-differences in reciprocity (turn taking, reciprocal interaction, reciprocal interaction in the experimenter's initiative, reciprocal interaction in own initiative, flexibility).

Finally, to deeper investigate the association between reciprocity and ToM in the separate age groups, we computed hierarchical linear regressions in each age group to determine which specific ToM component was associated to the different elements of reciprocity.

4.2. Age-related differences in executive functioning measures

The one-way ANOVAs revealed that younger adults had a significant higher inhibition ($F_{(1,114)}$ = 24.33, p<0.001) and greater shifting capacity ($F_{(1,114)}$ =40.69, p<0.001) than older adults.

4.3. Age-related differences in the creativity and reciprocity beliefs questionnaires

The results of the one-way ANOVAs indicated that there were no age differences in creativity ($F_{(1,114)}$ = 0.624, p = 0.431) , negative reciprocity ($F_{(1,114)}$ = 0.315, p = 0.576) and reciprocity beliefs ($F_{(1,114)}$ = 0.254, p = 0.615) between our two age-groups, but that older adults tended to be more prone to reciprocate positive actions than younger adults ($F_{(1,114)}$ = 12.49, p <0.001).

Concerning the first part of the IDT questionnaire no age differences were found in the perception of closeness ($F_{(1,114)}$ = 0.937, p = 0.335), emotional state ($F_{(1,114)}$ = 0.733, p = 0.394), metacognitive judgement ($F_{(1,114)}$ = 1.842, p = 0.177), motivation ($F_{(1,114)}$ = 1.382, p = 0.242) nor cooperation ($F_{(1,114)}$ = 0.518, p = 0.473) related to the IDT. On the other hand, older adults

were marginally less confident ($F_{(1,114)}$ = 3.474, p = 0.065) and perceived their drawing as significantly less meaningful ($F_{(1,114)}$ = 11.11, p = 0.0012) than younger adults.

Table 14 : Descriptive statistics of first part of the reciprocity questionnaire of the IDT beliefs

	Young adults		Old adults	
	Mean (SD)	Range	Mean (SD)	Range
Closeness	7.03 (1.84)	1-10	7.35 (1.7)	1-10
Emotional state	7.28 (1.4)	1-10	7.51 (1.49)	1-10
Metacognitive judgment	6.69 (1.44)	1-10	6.29 (1.94)	1-10
Motivation	8.22 (1.23)	1-10	8.48 (1.2)	1-10
Cooperation	7.4 (1.83)	1-10	7.66 (2.04)	1-10
Confidence	7.76 (1.88)	1-10	6.97^{+} (2.64)	1-10
Perception	7.52 (1.68)	1-10	6.33^{**} (2.14)	1-10

Note. The significant age differences are represented by p (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.07

4.4. Age-related differences in the ToM components

Intending to use the ToM variables as explanatory predictors for the eventual age-differences in reciprocity, it was important to first establish if there were age differences in the ToM dimensions measured by the Silent Film task, the Animation task, the Director task and the MPS-TOMQ. For this reason, we conducted ANCOVAs controlling for years of education on the aforementioned dimensions. The analysis demonstrated that older adults had more difficulties to understand false beliefs in the context of cooperation and deception (MPS-TOMQ: $F_{(1,119)}$ = 4.36, p = 0.04) than younger adults and that it was partially due to an effect of years of education ($F_{(1,19)}$ = 15.65, p <0.001). After controlling for the years of education,

no age related differences were found ($F_{(1,19)}$ = 2.53, p = 0.11) on the Silent Film task even if the effect of education ($F_{(1,19)}$ = 1.086, p = 0.3) was not significant.

Due to the nature of the Animation and Director tasks it is important to verify if the effect we find is truly a ToM effect. Consequently, two repeated measure ANOVAs were carried out. The 2 (conditions: ToM and Action) x 2 (age-groups: young or old) repeated measure ANOVA on the Animation task indicated that there was indeed a main effect of condition ($F_{(1,114)}$= 7.270, p= 0.008), a main effect of age ($F_{(1,114)}$= 83.769, p < 0.001) and an interaction effect of age and condition ($F_{(1,114)}$= 5.021, p= 0.026). As expected, the Tukey post hoc analysis proved that the participants had more difficulties in the ToM condition than in the action condition. Besides, it showed that older adults had more difficulties than younger adults to infer mental states in general. Furthermore, the post hoc test indicated that older adults performed worse in the action condition than younger adults in the ToM condition. For the director task a 2 (conditions: experimental and control) x 2 (age groups: young or old) repeated measure ANOVA evidenced a main effect of condition ($F_{(1,114)}$= 139.84, p < 0.001), a main effect of age ($F_{(1,114)}$= 100.52, p < 0.001) and an interaction effect of age and condition ($F_{(1,114)}$= 56.86, p < 0.001). Once again, the Tukey post hoc analysis highlighted that the experimental conditions were more difficult than the control condition especially for older adults.

4.5. Age-related differences in the reciprocity measures

A major objective of these analyses is to verify if there were age-related differences between young and older adults in behavioral reciprocity. Moreover, previously we demonstrated that the two groups varied significantly in their years of education. Therefore, we performed several ANCOVAs controlling for years of education as well as the confidence and perception of the drawing, on all the reciprocity measures of the IDT task: physical reciprocity (i.e. turn taking), collaborative reciprocity (i.e. reciprocal interaction, reciprocal interaction in the experimenter's initiative, and reciprocal interaction in the participant's own initiative),

reciprocal flexibility, and the total score, in addition to the measures of the second part of the IDT questionnaire, i.e., intentionality, awareness and accuracy.

Older adults indicated a lower reciprocal behavior in turn taking ($F_{(1,111)}$ =7.56, p =0.007), reciprocal interaction ($F_{(1,111)}$ = 5.10, p = 0.03), flexibility ($F_{(1,111)}$ = 5.47, p =0.021), the overall IDT score ($F_{(1,111)}$ = 12.29, p <0.001), the intentionality ($F_{(1,111)}$ = 6.64, p =0.011) and awareness ($F_{(1,111)}$ = 6.83, p =0.01). No effects of years of education, confidence nor perception of the drawing, were found for any of these variables ((1) Years of education : turn taking: $F_{(1,111)}$ = 0.367, p = 0.546; reciprocal interaction: $F_{(1,111)}$ = 0.580, p = 0.448; flexibility: $F_{(1,111)}$ = 0.001, p = 0.992; total score: $F_{(1,111)}$ =0.0001, p = 0.990; intentionality: $F_{(1,111)}$ = 0.079, p =0.78; awareness: $F_{(1,111)}$ = 0.226, p =0.636; (2) Confidence: turn taking: $F_{(1,111)}$ = 0.0029, p = 0.957; reciprocal interaction: $F_{(1,111)}$ = 0.0155, p = 0.901; flexibility: $F_{(1,111)}$ = 0.948, p = 0.332; total score: $F_{(1,111)}$ =0.0001, p = 0.990; awareness: $F_{(1,111)}$ = 0.68, p =0.411; (3) Perception of the drawing: turn taking: $F_{(1,111)}$ =0.0151, p = 0.903; reciprocal interaction: $F_{(1,111)}$ = 2.62, p = 0.108; flexibility: $F_{(1,111)}$ = 1.964, p = 0.164; total score: $F_{(1,111)}$ =1.135, p = 0.289; intentionality: $F_{(1,111)}$ = 0.172, p =0.679; awareness: $F_{(1,111)}$ = 0.741, p =0.39), except for an effect of confidence on the intentionality ($F_{(1,111)}$ = 4.694, p =0.032). Unlike the other measures, reciprocal interaction in the experimenter's initiative and in the participant's own initiative did not exhibit any age differences (experimenter's initiative: $F_{(1,111)}$ = 1.67, p = 0.198, own initiative : $F_{(1,111)}$ = 0.538, p =0.465) nor were there any effects of years of education (experimenter's initiative: $F_{(1,111)}$ = 1.21, p = 0.273, own initiative: $F_{(1,111)}$ = 0.0623, p = 0.803), confidence (experimenter's initiative: $F_{(1,111)}$ = 0.0495, p = 0.824, own initiative: $F_{(1,111)}$ = 0.250, p = 0.618), nor perception of the drawing in the experimenter's initiative ($F_{(1,111)}$ = 1.64, p = 0.204). However an effect of perception of the drawing was found in the participant's own initiative ($F_{(1,111)}$ = 4.762, p = 0.031). In the same way older and younger adults did not differ in understanding the contributions to the drawings (accuracy: $F_{(1,111)}$ = 0.002, p =0.97) nor was there an effect of

education ($F_{(1,111)}$= 0.51, p =0.48), confidence ($F_{(1,111)}$=0.716, p=0.399) or perception of the drawing ($F_{(1,111)}$=1.071, p=0.303) on the accuracy measure. The descriptive statistics are presented in Table 15.

Table 15 : Descriptive statistics of the reciprocity measures of the IDT task and perception questionnaire

	Young adults		Old adults	
	Mean (SD)	Range	Mean (SD)	Range
Turn taking	1.51 (0.5)	0-2	1.15** (0.61)	0-2
Reciprocal interaction	0.53 (0.16)	0-1	0.46* (0.22)	0-1
- In other's initiative	0.30 (0.12)	0-1	0.25 (0.19)	0-1
- In own initiative	0.23 (0.12)	0-1	0.21 (0.13)	0-1
Flexibility	0.49 (0.29)	0-1	0.32* (0.33)	0-1
Total score	2.82 (0.73)	0-5	2.17*** (0.79)	0-5
intentionality	9.40 (2.44)	0-15	7.82* (2.55)	0-15
awareness	12.1 (2.66)	0-20	10.4* (2.56)	0-20
accuracy	3.43 (1.2)	0-5	3.49 (1.26)	0-5

Note: The total score does not include the reciprocal interaction in own initiative.

The significant age differences are represented by p (***) < 0.001, (**) < 0.01, (*) < 0.05

4.6. Regression analysis to explain age-related differences

From the previous ANOVA and ANCOVA analyses on the age differences in executive functioning variables, ToM and reciprocity, we decided to test if the age-related differences in reciprocity measures of turn taking, reciprocal interaction, flexibility, intentionality, and

awareness could be explained by the age differences in the cognitive and ToM variables. We decided to use a composite score for ToM including the Director task, the MPS-TOMQ and both scores of the animation task ($\alpha = 0.714$). With this in mind, we ran a series of hierarchical regression analysis in three steps. The first step was a simple control for the age differences and, thus, only included the age groups. In the second step, the executive functioning variables were added. In the final step, the composite score of the ToM components was added to the predictors.

As shown in Table 16 the age differences in the reciprocity measures of turn taking, reciprocal interaction, and flexibility seem to be partially explained by executive functioning. Indeed, after adding the measures of shifting and inhibition we can see that the age differences remain for reciprocal interaction and flexibility but that shifting and inhibition, respectively, seem to play a role in this age difference. For the turn taking measure of reciprocity, shifting seems to mainly explain the age difference. However, adding the ToM score was not significant for any of the reciprocity dimensions but still seemed to influence the age difference in turn taking where it was not significant anymore. From the results of the regression analyses it seems that age differences in reciprocity are not entirely explained by executive functioning nor ToM.

Table 16: Hierarchical regression analysis to explain age-related differences

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Age groups	-0.421	0.102	-0.362***	-0.07	0.036	-0.181+	-0.202	0.055	-0.325***
Step 2									
Age groups	-0.204	0.118	-0.175+	-0.107	0.043	-0.273*	-0.194	0.066	-0.312**
Shifting	-0.002	0.001	-0.225*	0.001	0.0004	0.196+	0.0008	0.0006	0.143
Inhibition	-0.035	0.020	-0.171+	-0.001	0.007	-0.020	-0.023	0.011	-0.206*

Step 3									
Age groups	-0.194	0.142	-0.166	-0.080	0.051	-0.206	-0.141	0.078	-0.228^{+}
Shifting	-0.002	0.001	-0.218^{+}	0.001	0.0004	0.244^{*}	0.001	0.0006	0.203^{+}
Inhibition	-0.035	0.021	-0.167^{+}	0.001	0.008	0.008	-0.019	0.0114	-0.171
ToM	0.011	0.083	0.020	0.028	0.030	0.145	0.057	0.046	0.181
R^2	$R^2= 0.012^{***}$ for step 1 $\partial R^2=0.076^{**}$ for step 2 $\partial R^2=0.0001$ for step 3			$R^2= 0.024^{+}$ for step 1 $\partial R^2=0.027$ for step 2 $\partial R^2=0.007$ for step 3			$R^2= 0.098^{**}$ for step 1 $\partial R^2=0.039^{+}$ for step 2 $\partial R^2=0.012$ for step 3		
	IDT Total score			Intentionality			Awareness		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Age groups	-0.722	0.143	-0.427^{***}	-1.603	0.473	-0.302	-1.570	0.492	-0.286^{**}
Step 2									
Age groups	-0.547	0.170	-0.324^{**}	-1.019	0.569	-0.192^{+}	-1.789	0.599	-0.326
Shifting	-0.0004	0.002	-0.028	-0.008	0.005	-0.167	0.003	0.005	0.052
Inhibition	-0.064	0.029	-0.213^{*}	-0.056	0.096	-0.059	0.032	0.101	0.033
Step 3									
Age groups	-0.459	0.120	-0.272^{*}	-0.890	0.680	-0.168^{**}	-1.238	0.710	-0.225^{+}
Shifting	0.0001	0.002	0.009	-0.007	0.005	-0.150	0.006	0.006	0.123
Inhibition	-0.058	0.029	-0.191^{+}	-0.046	0.100	-0.049	0.073	0.104	0.075
ToM	0.095	0.119	0.112	0.140	0.399	0.052	0.596	0.417	0.217
R^2	$R^2= 0.175^{***}$ for step 1 $\partial R^2=0.040^{+}$ for step 2 $\partial R^2=0.004$ for step 3			$R^2= 0.083^{***}$ for step 1 $\partial R^2=0.027$ for step 2 $\partial R^2=0.001$ for step 3			$R^2= 0.070^{**}$ for step 1 $\partial R^2=0.004$ for step 2 $\partial R^2=0.017$ for step 3		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.07

4.7. Association between ToM components and reciprocity measures in young and old adults

After examining the possible origins of the decline, we decided to study the predictors of reciprocity in the different age groups. Consequently, we computed 2 steps hierarchical regression analyses. In the first step, we included the executive functioning measures of shifting and inhibition. In the second and last step, a ToM component was added. In order to avoid collinearity between the different ToM variables, we decided to add them in separate regressions.

We can see in Table 17, Table 18, Table 19, and Table 20 that for the young adults none of the models are significant. Therefore, for younger adults none of the measures are predicted by executive functioning or any of the ToM components.

Alternatively, a different pattern of predictors was found for older adults (see Table 21, Table 22, Table 23, and Table 24). The ability to contextually infer mental states to movie characters is a significant predictor of reciprocal flexibility and reciprocal interaction (see figure 8 B). The physical measure of reciprocity, i.e., turn taking, is significantly predicted by the executive function of shifting (see figure 8 A). Shifting and the understanding of false belief are significant predictors of reciprocal interaction in the participants' own initiative. Unfortunately, no other measures were significantly predicted by any executive functions nor ToM components.

Table 17: Hierarchical regression analysis in young adults with Silent Film as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	0.008	0.004	0.219	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.103	0.069	-0.193	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	0.007	0.005	0.219	0.002	0.002	0.208	-0.0006	0.003	-0.032
Inhibition	-0.103	0.070	-0.193	0.012	0.022	0.070	0.002	0.041	0.005
Silent Film	0.0008	0.033	-0.003	-0.008	0.011	-0.099	-0.019	0.020	-0.131
R^2	R^2= 0.051 for step 1			R^2= 0.005 for step 1			R^2= -0.033 for step 1		
	∂R^2=0.022 for step 2			∂R^2=0.009 for step 2			∂R^2=0.016 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.015	0.022	-0.086	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.583	0.348	-0.220	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	-0.017	0.022	-0.097	0.017	0.025	0.093	0.003	0.011	0.093
Inhibition	-0.600	0.352	-0.193	0.171	0.392	0.059	-0.150	0.173	0.059
Silent Film	0.082	0.168	-0.226	-0.088	0.187	-0.065	-0.125	0.082	-0.065
R^2	R^2= 0.022 for step 1			R^2= -0.026 for step 1			R^2= -0.018 for step 1		
	∂R^2=0.004 for step 2			∂R^2=0.004 for step 2			∂R^2=**0.040**$^+$ for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 18 : Hierarchical regression analysis in young adults with the Director task as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	0.008	0.004	0.219	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.103	0.069	-0.193	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	0.006	0.005	0.188	0.002	0.002	0.186	-0.0001	0.003	-0.006
Inhibition	-0.156	0.082	-0.290	0.007	0.027	0.043	0.043	0.048	0.143
Director	-0.042	0.037	-0.180	-0.002	0.012	-0.031	0.037	0.022	0.277
R^2	R^2= 0.051 for step 1			R^2= 0.005 for step 1			R^2= -0.033 for step 1		
	∂R^2=0.022 for step 2			∂R^2=0.0006 for step 2			∂R^2=0.051 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.015	0.022	-0.086	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.583	0.348	-0.220	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	-0.008	0.023	-0.051	0.019	0.026	0.102	0.001	0.012	0.102
Inhibition	-0.300	0.415	-0.113	0.330	0.467	0.114	-0.120	0.210	0.114
Director	0.229	0.186	0.196	0.144	0.209	0.113	-0.045	0.094	0.113
R^2	R^2= 0.022 for step 1			R^2= -0.026 for step 1			R^2= -0.018 for step 1		
	∂R^2=0.026 for step 2			∂R^2=0.009 for step 2			∂R^2=0.004 for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 19 : Hierarchical regression analysis in young adults with Animation task as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	0.008	0.004	0.219	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.103	0.069	-0.193	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	0.008	0.004	0.219	0.002	0.001	0.187	-0.0001	0.003	-0.057
Inhibition	-0.099	0.070	-0.187	0.006	0.022	0.036	-0.009	0.041	0.030
Triangle	-0.011	0.038	-0.038	-0.014	0.012	0.152	0.023	0.022	0.141
R^2	R^2= 0.051 for step 1			R^2= 0.005 for step 1			R^2= -0.033 for step 1		
	∂R^2=0.001 for step 2			∂R^2=0.022 for step 2			∂R^2=0.019 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.015	0.022	-0.086	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.583	0.348	-0.220	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	-0.015	0.023	-0.088	0.015	0.025	0.080	0.0002	0.011	0.080
Inhibition	-0.627	0.353	-0.236	0.105	0.394	0.036	-0.160	0.177	0.036
Triangle	0.153	0.192	0.106	0.165	0.213	0.105	-0.055	0.096	0.105
R^2	R^2= 0.022 for step 1			R^2= -0.026 for step 1			R^2= -0.018 for step 1		
	∂R^2=0.011 for step 2			∂R^2=0.011 for step 2			∂R^2=0.006 for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 20 : Hierarchical regression analysis in young adults with MPS-TOMQ as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	0.008	0.004	0.219	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.103	0.069	-0.193	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	0.007	0.004	0.195	0.002	0.001	0.182	-0.0009	0.003	-0.047
Inhibition	-0.114	0.067	-0.214	0.008	0.023	0.047	-0.0002	0.041	-0.0007
MPS-TOMQ	-0.031	0.016	**-0.251**$^{+}$	-0.004	0.008	-0.074	0.006	0.010	0.082
R^2	R^2= 0.051 for step 1			R^2= 0.005 for step 1			R^2= -0.033 for step 1		
	∂R^2=0.062^{+} for step 2			∂R^2=0.005 for step 2			∂R^2=0.007 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.015	0.022	-0.086	0.002	0.001	0.191	-0.001	0.003	-0.055
Inhibition	-0.583	0.348	-0.220	0.010	0.022	0.060	-0.002	0.041	-0.008
Step 2									
Shifting	-0.015	0.023	-0.086	0.015	0.025	0.081	-0.002	0.011	0.081
Inhibition	-0.583	0.353	-0.220	0.150	0.392	0.052	-0.198	0.173	0.052
MPS-TOMQ	-0.0007	0.082	-0.001	-0.007	0.092	-0.010	-0.060	0.040	-0.010
R^2	R^2= 0.022 for step 1			R^2= -0.026 for step 1			R^2= -0.018 for step 1		
	∂R^2=0.000001 for step 2			∂R^2=0.0001 for step 2			∂R^2=0.038 for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 21 : Hierarchical regression analysis in old adults with Silent Films as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.003	0.001	**-0.326***	0.0006	0.0004	0.188	0.0009	0.0006	0.196
Inhibition	-0.028	0.022	-0.166	-0.002	0.009	-0.031	-0.025	0.012	-0.282
Step 2									
Shifting	-0.003	0.001	**-0.355****	0.0008	0.0004	0.253	0.001	0.0006	**0.254**$^{+}$
Inhibition	-0.032	0.022	-0.188	0.001	0.008	0.021	-0.021	0.012	-0.237
Silent Film	-0.040	0.036	-0.143	0.035	0.014	**0.331***	0.042	0.019	**0.292***
R^2	R^2= **0.132**** for step 1			R^2= -0.002 for step 1			R^2= 0.056 for step 1		
	∂R^2=0.019 for step 2			∂R^2=**0.101*** for step 2			∂R^2=**0.078*** for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.008	0.005	-0.207	0.002	0.005	0.052	-0.001	0.002	-0.079
Inhibition	-0.017	0.102	-0.023	0.026	0.104	0.034	-0.011	0.045	-0.035
Step 2									
Shifting	-0.006	0.005	-0.158	0.003	0.005	0.081	-0.001	0.002	0.081
Inhibition	0.012	0.101	0.016	0.042	0.105	0.056	-0.009	0.046	0.056
MPS-TOMQ	0.311	0.168	0.249	0.176	0.174	0.142	0.030	0.077	0.142
R^2	R^2= 0.011 for step 1			R^2= -0.031 for step 1			R^2= -0.027 for step 1		
	∂R^2=0.057 for step 2			∂R^2=0.019 for step 2			∂R^2=0.003 for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 22 : Hierarchical regression analysis in old adults with the Director task as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.003	0.001	**-0.326***	0.0006	0.0004	0.188	0.0009	0.0006	0.196
Inhibition	-0.028	0.022	-0.166	-0.002	0.009	-0.031	-0.025	0.012	-0.282
Step 2									
Shifting	-0.003	0.001	**-0.321***	0.0007	0.0005	0.226	0.0008	0.0006	0.182
Inhibition	-0.028	0.022	-0.165	-0.001	0.009	0.022	-0.025	0.012	-0.285
Director	0.006	0.044	0.018	0.014	0.018	0.113	-0.007	0.024	0.041
R^2	R^2= **0.132**** for step 1			R^2= -0.002 for step 1			R^2= 0.056 for step 1		
	∂R^2=0.0002 for step 2			∂R^2=0.011 for step 2			∂R^2=0.002 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.008	0.005	-0.207	0.002	0.005	0.052	-0.001	0.002	-0.079
Inhibition	-0.017	0.102	-0.023	0.026	0.104	0.034	-0.011	0.045	-0.035
Step 2									
Shifting	-0.011	0.005	-0.297	0.003	0.006	0.096	-0.001	0.003	0.096
Inhibition	-0.032	0.101	-0.043	0.033	0.104	0.044	-0.011	0.046	0.044
Director	-0.385	0.202	-0.263	0.186	0.210	0.128	0.002	0.093	0.128
R^2	R^2= 0.011 for step 1			R^2= -0.031 for step 1			R^2= -0.027 for step 1		
	∂R^2=0.057 for step 2			∂R^2=0.014 for step 2			∂R^2=0.003 for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 23 : Hierarchical regression analysis in old adults with the Animation task as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.003	0.001	**-0.326***	0.0006	0.0004	0.188	0.0009	0.0006	0.196
Inhibition	-0.028	0.022	-0.166	-0.002	0.009	-0.031	-0.025	0.012	-0.282
Step 2									
Shifting	-0.002	0.001	**-0.268***	0.0005	0.0005	0.143	0.0008	0.0006	0.181
Inhibition	-0.016	0.022	-0.098	-0.005	0.009	-0.083	-0.027	0.012	-0.301
Triangle	0.073	0.041	0.238	0.021	0.017	0.182	-0.010	0.023	0.064
R^2	R^2= **0.132**** for step 1			R^2= -0.002 for step 1			R^2= 0.056 for step 1		
	∂R^2=0.046 for step 2			∂R^2=0.027 for step 2			∂R^2=0.003 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.008	0.005	-0.207	0.002	0.005	0.052	-0.001	0.002	-0.079
Inhibition	-0.017	0.102	-0.023	0.026	0.104	0.034	-0.011	0.045	-0.035
Step 2									
Shifting	-0.007	0.005	-0.196	0.002	0.006	0.043	-0.001	0.002	0.044
Inhibition	-0.007	0.108	-0.010	0.018	0.104	0.024	-0.009	0.048	0.024
Triangle	0.063	0.201	-0.046	-0.050	0.210	-0.037	0.015	0.089	-0.037
R^2	R^2= 0.011 for step 1			R^2= -0.031 for step 1			R^2= -0.027 for step 1		
	∂R^2=0.002 for step 2			∂R^2=0.001 for step 2			∂R^2=0.0005 for step 2		

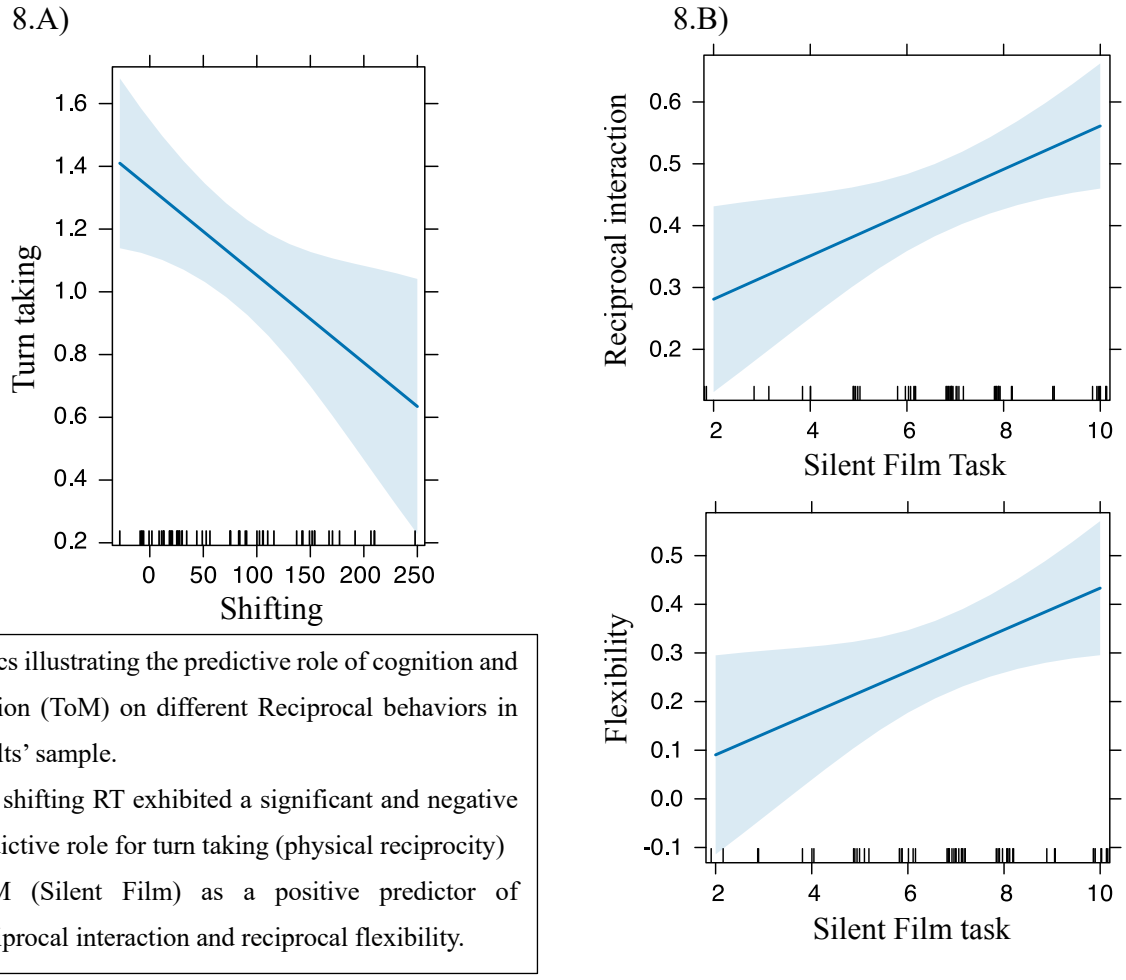
Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Table 24 : Hierarchical regression analysis in old adults with MPS-TOMQ as ToM measure

	Turn taking			Reciprocal interaction			Flexibility		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.003	0.001	**-0.326***	0.0006	0.0004	0.188	0.0009	0.0006	0.196
Inhibition	-0.028	0.022	-0.166	-0.002	0.009	-0.031	-0.025	0.012	-0.282
Step 2									
Shifting	-0.003	0.001	**-0.375***	0.001	0.0005	0.384	0.001	0.0008	0.286
Inhibition	-0.032	0.023	-0.192	0.005	0.009	0.074	-0.021	0.013	-0.234
MPS-TOMQ	-0.007	0.014	-0.087	0.011	0.006	0.350	0.007	0.008	0.160
R^2	R^2= **0.132**** for step 1			R^2= -0.002 for step 1			R^2= 0.056 for step 1		
	∂R^2=0.004 for step 2			∂R^2=0.062^{+} for step 2			∂R^2=0.013 for step 2		
	intentionality			awareness			accuracy		
Predictors	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**	**B**	**SE B**	**ß**
Step 1									
Shifting	-0.008	0.005	-0.207	0.002	0.005	0.052	-0.001	0.002	-0.079
Inhibition	-0.017	0.102	-0.023	0.026	0.104	0.034	-0.011	0.045	-0.035
Step 2									
Shifting	-0.009	0.006	-0.227	0.010	0.006	0.264	-0.003	0.003	0.264
Inhibition	-0.025	0.111	-0.034	0.109	0.109	0.147	0.028	0.047	0.147
MPS-TOMQ	-0.013	0.067	-0.035	0.135	0.066	0.376	0.064	0.029	0.376
R^2	R^2= 0.011 for step 1			R^2= -0.031 for step 1			R^2= -0.027 for step 1		
	∂R^2=0.0006 for step 2			∂R^2=0.072* for step 2			∂R^2=0.083* for step 2		

Note. *p* (***) < 0.001, (**) < 0.01, (*) < 0.05, (+) < 0.06

Figure 8 : Predictors of Reciprocity in older adults



Note. Graphics illustrating the predictive role of cognition and social cognition (ToM) on different Reciprocal behaviors in the older adults' sample.

A) The shifting RT exhibited a significant and negative predictive role for turn taking (physical reciprocity)

B) ToM (Silent Film) as a positive predictor of Reciprocal interaction and reciprocal flexibility.

5. DISCUSSION

Reciprocity is considered an essential component of social functioning and adequate social functioning is fundamental for a successful aging (Boggatz, 2016). Nonetheless little is known about the reciprocal behavior of older adults. Some studies have investigated how older adults perceive reciprocity in diverse relationships and how it affects them (Braun et al., 2018, Wahrendorf, 2010), and other studies have investigated the ability of older adults to detect reciprocity (Calso et al., 2019a, Calso et al., 2019b). These studies relied or on self-report questionnaires or on social observation. With this in mind, our study aimed at examining the reciprocal behavior of younger and older adults through an interactive ecological task. Moreover, an association between ToM and reciprocity (Fett et al., 2014; Schug et al., 2016), as well as cognitive functions (Calso et al., 2019a) and reciprocity, exists in the literature.

Therefore, the second aim of this study was to investigate if ToM and cognitive abilities could explain the age-related differences in reciprocal behavior between our two samples. Third, we verified if ToM was a predictor of reciprocity only in the different age groups like in our study on the MPS-TOMQ.

Since the meta-analysis we conducted revealed that ToM tasks measure different aspects of ToM we decided to use multiple tasks to assess several ToM components. The studied ToM components were: to understand true and false beliefs in cooperative and deceptive contexts, and to infer mental states without social cues, to infer mental states based on a social context, and the ability to take the other person's perspective. We, thus, used third- and second-person, visual-static, visual dynamic and verbal and visual-static tasks, along with cognitive and mixed ToM. Consequently, we covered several aspects of the ToM tasks in this study.

Our expectations for the first aim turned out to be accurate, older adults showed a lower physical, collaborative and flexible reciprocal behavior than younger adults. These results are in line with the previous literature on the detection of reciprocity. Interestingly, the decline found in the observational stance was replicated in this study using an interactive ecological task, which indicates that the decline is not related to the perspective of the respondent or the ecological validity. Therefore, we investigated the possible causes of this decline, based on the associations of reciprocity with ToM and cognitive measures and the determinants brought forward in the review of Henry et al. (2023), such as capacity (cognitive abilities), motivation and context.

This study established no differences in the reported motivation, perception of closeness and metacognitive judgement between younger and older adults in the IDT. Older adults were less confident, but it did not influence their reciprocal behavior. Additionally, contrary to our hypothesis, the ToM measures did not explain the age-related loss in reciprocal behavior. However, the cognitive measure of shifting was a significant or close to significant predictor of

the age-related decline in physical, collaborative and flexible reciprocal behavior. This could be explained by the fact that reciprocity is cognitively demanding which corroborates that a cognitive decline can be the cause of the social cognitive decline, as indicated in the review of henry et al. (2023). Moreover, considering the high levels of motivation and feelings of closeness for the older adults' sample, we believe that older adults valued the task of the study as rewarding. Therefore, two potential explanations for the decline could be explored: it could be attributed to a cognitive decline, as addressed above, or to the stimulation of cognitive functions by complex social interactions (Bennett et al., 2006).

Only the age-related decline in flexibility was not entirely explained by the cognitive measures. Indeed, older adults had a difficulty to adapt to a change in the drawing initiated by the experimenter, that was not explained by ToM or cognitive functions. Maybe this could be explained by individuals egocentric bias when they are not explicitly asked to take another person's perspective (Martin et al., 2019, Mattan et al., 2017) which could lead to a difficulty to interpret a proposed change in contribution. As we demonstrated in our study on spontaneous perspective-taking older adults seem to have a stronger implicit egocentric bias, since they took more time to take another person's perspective. This could be an interpretation for the lack of association with the director task, for which we considered the results to the explicit demand. It could therefore be interesting to assess an implicit perspective taking task or to interpret the reaction times of the director task in future studies.

For our last hypothesis the outcome of our regression analysis on the different age groups demonstrated that younger adults' physical reciprocal behavior was close to significance and negatively predicted by the understanding of false belief in a context of deception and cooperation. So, a younger adult with a higher ability to detect cooperation, deception and cheating, along with a better understanding of true and false belief, was less likely to turn and push the page back to the experimenter. However, younger adults' cooperative and flexible

reciprocal behavior was likely neither linked to the cognitive measures of shifting and inhibition, nor to any ToM measures.

On the other hand, the pattern of association was different for older adults and more in line with the literature (Calso et al, 2019; Schug et al, 2016). The ability of the older sample to shift fast enhanced their physical reciprocity. From this we can assume that older adults that are faster at shifting between stimuli, are better at switching turns and thus physically hand the paper over to the experimenter. Even more interestingly, older adults with a higher ability to contextually infer mental states to a character in a silent film, were better at contributing to meaningful drawings together with the experimenter and to change their intention of drawing to adapt to the contribution of the experimenter. These associations could be explained by the fact that in both tasks the participant is asked to appropriately infer intentions to the character (for the silent films) and the experimenter (for the IDT) within the context of the film or the drawing. Thus, an older adult that has a greater ability to infer mental states by observing a context, will be better at pursuing someone else's intention or at working together for a common goal.

As previously acknowledged, one of the limitations of this study is that the experimenter was the one using the mouse in the director task, which prevented us from using the reaction time as an implicit measure of the task. In a further study, it would be better to simplify the task by asking participants to only click on the object rather than to fully move it. In addition, further research could also test implicit and explicit visual perspective-taking and see if a possible link with reciprocity comes forward. Another limitation could be the number of participants, but this study being the first one to research reciprocal behavior in an interactive context, it was important for us to understand the trend of the results.

To sum up, this study determined that the age-related decline found in reciprocity of an observational task was present in an interactive ecological task. Older adults showed lower

reciprocal behavior compared to younger adults. Furthermore, the study exhibited that the age-related differences were explained by the cognitively demanding aspect of the task but not by ToM. Nevertheless, an association between ToM and cooperative as well as flexible reciprocity was found in older adults. This study is thus the first, to uncover this association and decline in an interactive ecological task. We thus hope that further studies will continue investigating social functioning through more interactive settings.

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Chapter VIII. General discussion

1. SUMMARY OF THE RESULTS

The general aim of this thesis was to investigate the association between social cognition, more specifically ToM, and social functioning in aging. Additionally, across four different studies, this thesis questions the operationalization of the tasks, namely, their ecological validity and observational stance, representing a critical issue by potentially reinforcing the age-related decrease in older adults' abilities. To this end, we first conducted a meta-analysis to examine the possible effect produced by the ecological validity of the ToM tasks on older adults' performance. Then, we measured both ToM and social functioning in younger and older adults through more ecological instruments.

The first study of this thesis was a meta-analysis that aspired to capture all the new developments of the ToM concept studied in older adults compared to younger adults. We performed a multivariate meta-analysis to evaluate the effect of the task parameters on the age-related differences. Therefore, we conducted meta-regressions to test if the age decline was partially explained by ecological validity (dynamicity, real agent, multimodality) and the perspective of the respondent (first-, second-, and third-person), along with several other moderators such as the task type, the domain and the modality. The meta-analysis included 110 tasks retrieved from 64 papers and resulted in no effect of the moderators but a great variance between the different tasks. From this second meta-analysis on the subject no main changes arose in the results. Similarly, to the meta-analysis of Henry and colleagues (2013) the age decline seemed to persist over all the diverse parameters of the tasks since no moderators were identified. Although, these results should be taken with some reservations concerning the perspective of the respondent and the ecological validity in view of the high percentage of tasks with a third-person perspective and with low ecological validity, along with very few virtual reality and perspective-taking tasks. Overall, the meta-analysis did inform us that the global

literature on the age decline in ToM performance is not moderated by the effect of domain, task type or modality but that the ToM tasks measure different components of ToM. It is therefore entirely appropriate to use several ToM tasks in a study. Further results are needed to fully answer our question on the methodological effect on age variation between younger and older adults even if an underlying deficit in ToM seem to exist in older adults. Nevertheless, this meta-analysis emphasizes the need for more interactive tasks with a higher ecological validity.

Indeed, as put forward in the above referred meta-analysis, a limited number of studies use high ecological approaches. Consequently, in a second study, we decided to address age-related differences through an uncued spontaneous perspective-taking task. Furthermore, considering the possible influence of social context on social cognitive abilities, we simultaneously assessed cultural differences comparing samples from individualistic and collectivistic cultures. In opposition with our hypothesis, older adults did not significantly differ from younger adults in their tendency to take their own perspective (first person) for static-oriented tasks and the alter-centric (third person) perspective for tasks with a movement-oriented demand in both cultures. However, older adults took significantly more time than younger adults to choose the third-person perspective in the movement-oriented tasks. This could be a sign of an egocentric bias, suggesting that older adults have more difficulties to switch towards the other's perspective, which is in line with the literature (Martin et al., 2019; Mattan et al., 2017). Moreover, the study revealed a cultural difference between individualistic and collectivistic participants, indicating that collectivistic individuals had a greater tendency to take their own perspective. This outcome strengthens the representational hypothesis which posits that collectivistic individuals will favor the self-perspective considering that the other- and self-perspective are interchangeable (Wu & Keysar, 2007). No interaction effect between age and culture was found. This study helped us understand that age-related differences in an ecological implicit perspective-taking task were more subtle. The difference did not lie within

the tendency for individuals to take a perspective but within the amount of time it takes them, understanding that older adults are slower in taking the third-person perspective. This study is very interesting because it allows us to perceive that in spontaneous and so less cognitively demanding tasks, older adults can take a third-person perspective. This task has maybe a higher ecological validity and approximation of a real-world situation than other perspective-taking tasks. It reports that the approach of the task can have an influence on the answer, by, in this case, showing a similar tendency in younger and older adults, giving us more insight on our considerations on methodology. In sum, this study helps rethink the assessment of the tasks to better identify the sources of the age-related disparities.

After considering the ecological issues in assessing social cognitive abilities, we initiated the research on age-related impairments in social functioning and its possible associations with social cognition. In social interactions it is important to understand and infer mental states to others, as debated in the two previous studies, as well as appropriately engage with, maintain, and reciprocate others' social behaviors. Therefore, the third study analyzed the differences in detection of distinct components of reciprocity (deception, cooperation, and cheating) between young, middle-aged, and older adults. In addition, it investigated the possible predictive effects of cognitive functions, personality and true and false belief understanding on the reciprocity dimensions in each age group. It is unique in being one of the rare studies on reciprocity performance in older adults and proposing an analysis of the reciprocity components by story context (deceptive, cooperative, or mixed). The analysis demonstrated that younger and middle-aged adults had a greater ability to detect cooperation in cooperation stories, deception in both deceptive and mixed stories, and cheating. The main outcome was consistent with the literature (Calso et al., 2019a, 2019b; Raimo et al., 2022) stating that from 65 years of age individuals display a lower ability to detect reciprocity. With regard to the possible predictors of reciprocity, a different pattern was found between the age-groups. For younger

adults, working memory, empathic concern, and true and false belief significantly and marginally (for the ToM measures) predicted the detection of reciprocity. Furthermore, middle-aged adults' working memory, agreeableness and true and false belief were significant and marginal (for the personality disposition) predictors of the detection of reciprocity. Finally, for older adults it is their ability of abstract reasoning, working memory, and true and false belief understanding that had a significant predictive effect on their ability to detect reciprocity. Older adults were the only group to show a different cognitive pattern for cooperation and deception as highlighted in the literature (Lissek et al., 2008). This study on detection of reciprocity provided an acknowledgment of the older adults' difficulty to perceive reciprocity in both a cooperative and a deceptive context. Moreover, it higlighted an effective association between social cognition, measured by ToM, and social functioning, assessed through a reciprocity detection task, giving some food for thoughts to our aims. Even more interestingly, the outcome of the regression revealed that older adults rely on cognition and social cognition above personality to detect reciprocity.

Finally, in the fourth and last study, we adopted a second-person interactive approach in contrast with the literature in which most studies investigating social functioning and social cognition applied third-person social observational approaches. Thus, the study investigated the reciprocal behavior of younger and older adults with an interactive ecological task, along with a possible partial effect of ToM and cognition on this behavior. Furthermore, it considered the probable link between ToM and reciprocity in the different age groups. This study contained several aspects of the previous three studies. It investigated age-related differences in reciprocal performance through a new interactive task analogous to real-life social situations asking older adults to take the first, second and third-person perspectives into account. Besides, it measured several ToM abilities to look at their possible association with reciprocal behavior, knowing from our meta-analysis that ToM is a multimodal component. The first outcome revealed that

older adults did manifest lower physical, cooperative, and flexible reciprocal behaviors compared to younger adults. We, thus, found persisting results of reciprocal decline in older adults' reciprocity performance substantiating our previous study (study 3), and the past literature (Calso et al., 2019a; Calso et al., 2019b.; Raimo et al., 2022). Importantly, this study revealed no difference in motivation, perception of closeness and metacognitive judgment between younger and older adults, for whom all these variables were quite highly evaluated. However, older adults showed a lower confidence in their performance, but it did not have any significant influence on their ability to reciprocate. These factors of self-reported beliefs on their performance were closely measured due to the possible effects of motivation and context on older adults' performance highlighted in a review from Henry and colleagues (2023). Regarding the possible implication of the decline in cognition and ToM on the found age-related differences in reciprocal behavior, only the cognitive measures of shifting explained the age-related difference in physical and collaborative reciprocity and partially in flexible reciprocity. Thus, this indicates that reciprocity could be cognitively demanding and that a cognitive decline could be the cause of a social functioning decrease. The reciprocal flexibility decline is partially explained by cognition and could be associated to an implicit egocentric bias, as seen in the study on spontaneous perspective-taking. It emphasizes the difficulty of older adults to actively change the intention of the drawing to match the intention of the other person. The regression analysis, divided by age groups, revealed that younger adults' physical reciprocal behavior was negatively predicted by their ability to detect cooperation, deception, and cheating, along with their understanding of true and false beliefs. Furthermore, it revealed that older adults' rapid ability to shift was predictive of physical reciprocity. Not to mention that their ability to infer mental states contextually and appropriately, as in the Silent film task, was a betoken of older adults' capacity to contribute to meaningful drawings (collaborative reciprocity) and ability to change and adapt their contribution to the intention of the experimenter (flexible reciprocity).

Altogether, this study on reciprocal behavior permits us to further develop the central aim of this thesis by presenting an age-related decrease in reciprocal behavior that does not seem to be explained by an age-related variation in ToM performance, even though an association between ToM and reciprocity has been found solely in older adults. Moreover, this study showed that age-related declines were still found in a more ecological and interactive task which could be evidence of a decline exceeding the effects generated by the operationalization of social functioning as discussed in the meta-analysis. In conclusion, the persistent age-related decrease on performance in a higher ecological and interactive task enhancing the motivation of the sample, encourages the use of such an approach to further investigate older adults' difficulties in social interactions.

2. LIMITATIONS AND FUTURE DIRECTIONS

A limitation of the meta-analysis in this thesis would be the lack of consideration of the effect of cognitive measures such as executive functioning and sample characteristics, for example, education and vocabulary, on the ToM tasks, which have been shown to influence older adults' abilities in social cognition (cognitive measures: Charlton et al., 2009; Otsuka et al., 2021; Saltzman et al., 2000; Saryazdi et al., 2020; Yildirim et al., 2019; sample characteristics: Fliss et al., 2016; Lecce et al., 2018; Li et al., 2013; Yong et al., 2022).

The limitations for the study on cultural and age-related differences in spontaneous perspective taking were threefold. First, there was a lack of cognitive measures to verify the cognitive demands of the task and the possible divergent cognitive uses in a static demand task compared to a movement-oriented task. Second, the use of one movement-oriented task in contrast to three static-oriented tasks limited the observation. Third, the difference in number of participants per culture could have influenced our results.

Moreover, a constraint of the third study would be to test reciprocity in just one modality (visual-static) when older adults have shown higher difficulties in detecting visual modalities over audio and audiovisual modalities in research on deception (Sun et al., 2020).

Finally, the strongest limitation of the study on reciprocal behavior would be the use of only explicit tasks whereas the drawing had some implicit engagements.

Taking these limits and the outcomes of the studies into consideration, it would be interesting for future research to integrate more implicit studies of social cognition and social functioning and to compare them with explicit tasks in older adults. Sabbagh and Bowman (2018) highlighted, in their review on theory of mind, that to investigate both implicit and explicit demands of ToM could help resolve the doubt on whether the difficulty lies in the explicit demand or in the underlying resources needed to understand the concept that is assessed.

An additional future direction would be to continue using interactive tasks mirroring real-world demands to reduce the possible effect of capacity and lack of motivation that can be created in lab circumstances, following the model proposed by Henry et al. (2023). Thus, enhancing older adults' motivation could lead them to provide more cognitive resources to fulfil the task and see it as more rewarding. The literature on social cognition and functioning started to lose the social aspect of their research by mainly studying social observation over social interaction. This thesis would, therefore, like to emphasize the use of multiple perspectives in a social functioning study to apprehend all aspects of social exchanges.

This leads us to another possible future study, a meta-analysis including the characteristics of the sample, namely, level of education, vocabulary, or cognitive measures. As could be seen in the second section of this study, the cognitive measures of reasoning, working memory, and shifting were significant predictors of the social functioning. Thus, it seems to have a strong impact on social exchanges which could be attributable to the context of the tasks,

i.e., lab settings, not approximating real-life, or to the effective cognitive decline found in older adults.

Lastly, this thesis started to explore the decrease in social functioning performance and its association to social cognition. Consequently, it would be interesting for future studies to continue researching this association and other links to determine the reasons behind the decline in social functioning of older adults.

3. CONCLUSION

With this thesis, I aimed at returning to a more social and ecological setting to investigate social functioning and its link to social cognition. It started by investigating the state of the art in age-related differences in Theory of Mind (ToM), to acquire a general vision and draw conclusions on the said difference, the operationalization of ToM, along with the approach in which the concept of ToM is considered. From this meta-analysis we deduced that age-related differences remained despite the multimodal aspect of ToM, but that ToM had mostly been assessed in social observation with poor ecological validity. Second, a study on spontaneous perspective was conducted to examine the tendency to spontaneously take another person's perspective in younger and older adults. This task simulated some real-life social contexts in which it is important to take multiple points of view into consideration even if we are not asked to do so. From this paper, we gathered that younger and older adults had the same tendencies to adopt other- and self-perspectives but that the latter demonstrated a higher egocentric bias and were thus slower in taking the third person perspective. Afterwards, a first study on social functioning was administered which indicated that a decline in reciprocity was present in 65 years old and over. In addition, a different pattern of predictors in older adults showed that cognitive abilities and ToM were at least partially responsible for their ability to detect reciprocity. Last but not least, an interactive study on reciprocal behavior confirmed the age-related differences in reciprocity between younger and older adults which were partially

explained by cognitive measures but not by ToM. Nevertheless, ToM was a partial predictor of physical, collaborative, and flexible reciprocity in older adults.

This thesis provides multiple insights on social cognition and functioning in older adults. It is the first to study social functioning through an interactive second-person ecological and implicit reciprocity task and consequently to confirm the age-related decline in social functioning and its association with social cognition in older adults. Furthermore, this thesis allows us to hypothesize that the decline in social functioning is partially based on cognition and an underlying mechanism specific to the concept.

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