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Abstract

Objective: We examined time perspective in patients with amnesic mild cognitive impairment (aMCI). Prior research has shown that aMCI is associated with difficulties in experiencing time duration and succession. However, this line of inquiry has not been extended to time perspective. We examined associations between aMCI and multiple dimensions of time perspective including perceived orientations and relationships among the past, present and future.

Method: Thirty aMCI patients and 33 healthy controls participated. Measures were the Time Orientation Scale (TOS), the Time Relation Scale (TRS), and the Zimbardo Time Perspective Inventory (ZTPI), as well as a comprehensive neuropsychological evaluation.

Results: The TRS was associated with aMCI. Patients with aMCI were more likely to perceive that time was unrelated than the healthy older adults. Among patients with aMCI, an unrelated time perspective was associated with poorer performance in executive function measures. However, aMCI was not associated with the TOS or the ZTPI.

Conclusions: Patients with aMCI have difficulty in perceiving relationships among the past, present, and future. This could be the consequence of deficits in executive functions. This research suggests that patients with aMCI may have limited understanding for how their current behaviours are related to both their past and future.

Keywords: Memory; Cognitive Decline; Executive Functions; Time Orientation; Time Relation; Time Perspective.

Time Perspective and amnestic Mild Cognitive Impairment

As a consequence of the ageing population, the number of people affected by neurodegenerative disorders, particularly Alzheimer disease (AD), is increasing dramatically worldwide. It is estimated that 55.2 million people were living with dementia worldwide in 2019, and this number will raise to 139 million by 2050 (World Health Organization, 2021). As a result, the importance of recognizing patients at initial stages of the disorder, before dementia develops, has been emphasised (de Mendonça, 2012). Amnestic Mild Cognitive Impairment (aMCI), a precursor to a diagnosis of AD, is characterized by subjective memory complaints, objective memory deficit, normal general cognitive performance, and maintained activities of daily living (Petersen *et al*., 1999). A diagnosis of aMCI enables the identification of patients at the greatest risk of dementia. Indeed, patients diagnosed with aMCI in a clinical setting have about 10% annual progression rate of conversion to dementia, and this is usually AD (Mitchell & Shiri-Feshk, 2009).

Patients at the initial stages of AD often refer to losing track of the date, season and the passage of time (Alzheimer's Association, 2019). As consequence of episodic memory impairment, difficulties in placing events in the correct temporal framework occur (Fouquet *et al.,* 2010). Orientation and daily planning may be compromised, since time perception is a crucial component of everyday decisions and goal-oriented behaviours (Buhusi & Meck, 2005; Mangels & Ivy, 2001). However, research on time perception in patients with aMCI has been limited.

Psychological time, the way we perceive time, encompasses at least three concepts: *duration*, that is, how long an event lasts; *succession*, meaning the order or the sequential occurrence of events; and *perspective*, referring to our impressions, thoughts and actions concerning the past, present and future (Block, 1990). Regarding *duration*, patients with

aMCI showed no alterations in their perception of interval length, evaluated either by time estimation or by time production (Coelho *et al.*, 2016; Maaß *et al.*, 2019; Mioni *et al*., 2019; Rueda & Schmitter-Edgecombe, 2009; Mioni *et al*., 2021), as compared to healthy controls. However, in the subjective passage of time judgments, patients with aMCI reported feeling time passing more slowly (Coelho *et al.*, 2016). Regarding *succession*, there is evidence that temporal order is impaired in patients with aMCI, indicating difficulty in acquiring and retaining the order of events (Gillis *et al.*, 2013). As far as we know, no studies have been conducted on time *perspective* in patients with aMCI.

Research on time perspective seems crucial since the conceptions about the past, the present and the future influence decisions, goal setting and emotions and motivate human behaviour (Janeiro, 2012; Carstensen, *et al.*, 1999; Mello, 2019; Zimbardo & Boyd, 1999). For instance, a strong focus on the past may lead us to learn from our mistakes and be more careful in future choices, whereas a strong focus on the future may be good for pursuing long term goals, such as academic achievement (Horstmanshof & Zimitat, 2007; Zimbardo & Boyd, 1999).

Time perspective has been operationalized in multiple ways and evaluated using diverse instruments. One of the most frequent conceptualizations comes from Zimbardo and Boyd (1999) who generated the Zimbardo Time Perspective Inventory (ZTPI). The ZTPI measures the beliefs, the thoughts and the hedonic values one has toward the past, present, and future. Other dimensions of time perspective include *Time Orientation*, the preference towards a particular time period (Cottle *et al.*, 1967; Mello & Worrell, 2015; Nuttin & Lens, 1985) and *Time Relation*, the perceived relationships among the past, the present and the future (Cottle *et al.*, 1967; Mello & Worrell, 2015). The Time Orientation Scale (TOS) and the Time Relation Scale (TRS) were designed to measure these time perspective dimensions (Mello, *et*

al., 2013). The TOS evaluates the dominance of one or more time dimensions over the others and the TRS addresses the relationships among the past, the present and the future as perceived by the individual. More specifically, the TOS and TRS dimensions determine how individuals perceive the past, present, and future by asking participants to indicate the time period(s) that are most important relative to other time periods (TOS) and the way that time periods are related to one another ranging from unrelated to completely related (TRS). Originally, studies examined associations among Time Orientation, Time Relation, and key developmental outcomes, such as academic achievement, psychological well-being, and risk taking with children and adolescents (Cottle *et al.*, 1967; Mello, *et al.*, 2013). Findings have generally indicated that higher academic achievement, higher self-esteem, and lower risk-taking (e.g., staying out late or skipping school) were associated with participants who perceived that the time periods were related to one another (time relation) and who thought that the multiple time periods were important, including the present and future or all time periods (time orientation; Cottle, 1969; Mello, *et al.*, 2013; Mello *et al*., 2021). Later, the scope of the studies using the scales was widened to include other age groups, such as adults (Thompson & Fitzpatrick, 2008) and older adults (Mello *et al*., 2021).

Combined, research on time perspective has posited that the construct includes multiple time periods (past, present, and future) and dimensions (orientation, relation, hedonism; Mello & Worrell, 2015; Zimbardo & Boyd, 1999). The advantage to this conceptualization is that one may assess the three time periods and multiple dimensions at the same time. In contrast, other approaches aim at capturing particular aspects of temporal preferences by considering the time dimensions separately. For instance, the Temporal Focus Scale (TFS, Shipp *et al.*, 2002) evaluates the degree of commitment to each time dimension, measuring the frequency with which the respondent thinks about the three time dimensions (e.g. “I focus

on what is currently happening in my life"). On the other hand, the Time Orientation Scale (TOS, Bowles, 1999) assesses the appreciation an individual has about his/her past, present and future, by classifying the level of agreement about the awareness, clarity, understanding, certainty and confidence regarding the three time dimensions (e.g. "I am clear about my future").

Researchers have proposed a close link between time perspective and higher cognitive functions (Zajenkowski *et al*., 2015). Time perspective requires cognitive resources associated with memory encoding, retrieving and updating, in order to establish mental representations of events and ascribe them to a specific time frame (Witowska & Zajenkowski, 2019). Patients with aMCI, by showing deficits in episodic memory (Ribeiro *et al*., 2006), would have difficulties in accessing these events and develop a correct perspective regarding past, present and future. Notably, the process of assigning experience to a particular time frame may also involve executive functions (Witowska & Zajenkowski, 2019).

A previous study in healthy adults, who completed a questionnaire of time passage and the ZTPI, found a relationship between subjective passage of time judgments and time perspective (Wittmann *et al.*, 2015). More precisely, this study showed that participants reporting an everyday faster passage of time displayed a stronger future perspective. Other research has shown that patients with aMCI report time passing slower when producing subjective passage of time judgments compared to healthy controls (Coelho *et al.*, 2016).

The Present Study

In this study, we sought to draw from the multidimensional conceptualization of time perspective (Mello & Worrell, 2015; Zimbardo & Boyd, 1999) in order to provide a nuanced and comprehensive examination of its association with aMCI. Drawing from the extant literature, as described above, we expected that patients with aMCI, by virtue of their illness,

may differ in time perspective from healthy controls. Specifically, we hypothesised that patients with aMCI, by feeling an everyday slower passage of time (Coelho *et al.*, 2016), might show a biased individual preference towards the past in the TOS. Further, taking into account the relevance of memory functions to time perspective (Witowska & Zajenkowski, 2019; Zajenkowski *et al*., 2015), we hypothesized that patients with aMCI would be hindered in perceiving the relationships among past, present and future in TRS, as compared to their healthy aged peers. Lastly, we expected the ZTPI would also indicate differences between patients with aMCI and healthy adults.

Methods

Procedure

Patients with aMCI were recruited from a memory clinic, (blind to the reviewer), where they underwent clinical history, neurological examination, laboratorial evaluation, brain imaging (CT scan or NMR scan) and a neuropsychological assessment. Controls were volunteers with no cognitive complaints from senior universities in (blind to the reviewer). The study was approved by the ethics committee of (blind to the reviewer), in 14/11/2021, reference number 381/17. The participants have provided appropriate informed consent using the written consent form approved by the ethics committee. Only group analyses were included in the manuscript, so that identification of individual participants should not be possible

The study was conducted according to the Helsinki declaration.

Participants

For all participants (63 in total), we included individuals who were Native (blind to the reviewer) speakers, had ≥ 4 years of schooling, and were older than 50 years of age. The inclusion criteria for the 30 patients with aMCI was adapted from (Petersen *et al.*, 1999) and included the following: (1) Presence of memory complaints at the clinical interview,

reflecting a change in cognition reported by patient, informant or clinician; (2) Abnormal memory function, beyond that expected for age and education, documented by the Logical Memory subtest of the *Bateria de Lisboa para Avaliação das Demências* (BLAD, see below); (3) Normal general cognitive function, determined by a Mini Mental State Examination (MMSE) within normal values for the (Blind to the reviewer) population (see below); (4) No impairment or minimal impairment in activities of daily living determined by the Instrumental Activities of Daily Living Scale (IADL), i.e., no more than one item from the IADL scale was abnormal (see below).

The control group (33 participants) followed the inclusion criteria: (1) Absence of memory complaints; (2) Normal memory function, documented by the Logical Memory subtest of BLAD; (3) MMSE within normal values for the (blind to the reviewer) population; (4) Normal score on the IADL scale, that is to say, no item from the IADL scale was altered.

Exclusion criteria included the following. (1) Dementia, according to DMS-IV-TR (American Psychiatric Association, 2000); (2) Presence of major depression according to DSM-IV-TR or serious depressive symptoms (indicated by a score on the Geriatric Depression Scale, 15 items version, >10 points); (3) Neurological disorders (Parkinson's disease, stroke, tumours, significant head trauma and epilepsy), psychiatric conditions (such as autism, schizophrenia), or uncontrolled medical illness (hypertension, metabolic, endocrine, toxic and infectious diseases) able to interfere with cognition and thus time perception; (4) Psychoactive medications with possible influence on cognition and thus time perception; (5) History of alcohol and drug abuse; (6) Sensory deficits likely to interfere with assessment.

Measures

Neuropsychological evaluation

Mini-Mental State Examination (MMSE, Folstein *et al.*, 1975) was used for evaluation of the mental state and screening of dementia. The (blind to the reviewer) version of the test adapted from Guerreiro *et al.* (1994) was used. Participants with MMSE below education-adjusted values for the (blind to the reviewer) population were excluded (<23 for less than or equal to 11 years of education, <28 for more than 11 years of education).

Logical Memory Test, which evaluates verbal memory abilities. This test is from Wechsler Memory Scale (Wechsler, 1945) and is included in *Bateria de Lisboa para Avaliação das Demências* (BLAD) (Garcia, 1984; Guerreiro, 1998), a neuropsychological battery designed to evaluate multiple cognitive domains and validated for the (blind to the reviewer) population. Participants with Logical Memory A (immediate or delayed recall) below education and age adjusted values for the (blind to the reviewer) population (1 SD) were considered impaired. A cut-off value of 1 SD was adopted because the cut-off value of 1.5 SD (Petersen *et al.*, 1999) could exclude subjects that suffered from aMCI (Palmer *et al.*, 2003; Winblad *et al.*, 2004).

Trail Making Test (TMT, Reitan, 1958). The TMT is a tool that evaluates executive functions, namely attention switching, planning and internal ordering. It consists of two parts. In part A, the subject is instructed to connect a set of 25 numbers as fast as possible while still maintaining accuracy. In part B, the subject is instructed to connect numbers sequentially with letters. Scoring is expressed in terms of the time in seconds for Part A and Part B of the test. Three hundred and sixty seconds was considered the maximum time. The (blind to the reviewer) version of the test, adapted from Cavaco *et al.* (2013), was used.

Digit Span Forward and Backward are tests from the Wechsler Memory Scale (Wechsler, 1945) included in the neuropsychological battery BLAD (Garcia, 1984; Guerreiro, 1998) and evaluate executive functions, namely attention and working memory.

The score varies from 0 to 9 for digit span forward and 0 to 8 for digit span backward, according to the number of digits repeated. A second attempt is given when the subject fails the first one.

Clock-Drawing Test from BLAD (Garcia, 1984; Guerreiro, 1998) was used to assess visuo-constructive and executive abilities and also for screening of cognitive impairment. The subject is asked to draw a clock without a model *Draw a clock, put in all the numbers and set the hands to indicate any hour*. The score varies from 0 to 3 depending on the accuracy of the clock design.

Memory Complaints Scale (SMC, Schmand *et al.*, 1996) is a questionnaire that assesses memory complaints. The SMC comprises 10 self-report items concerning difficulties in daily life memory tasks with total scores ranging from 0 (absence of complaints) to 21 (maximum complaints score). The (blind to the reviewer) version of the test adapted from Ginó *et al*. (2008) was used.

Geriatric Depression Scale (GDS, Yesavage & Brinks, 1983). The GDS is a questionnaire that evaluates the existence and the degree of depressive symptomatology. The version with 15 items was chosen (Sheikh & Yesavage, 1986). The scale consists of self-reported dichotomic questions (yes-or-no). The scores range from 0 (absence of depressive symptoms) to a maximum of 15 and a score >10 is considered to reflect serious depressive symptoms. The (blind to the reviewer) version adapted from Barreto *et al*. (2008) was used.

Satisfaction With Life Scale (SWLS, Diener *et al.*, 1985). The SWLS is a 5 item questionnaire that assesses global cognitive judgements of satisfaction with one's life, using a 7-point Likert scale, from *strongly agree* (7 points) to *strongly disagree* (1 point). The range

of scores is from 5 (low satisfaction) to 35 (high satisfaction). The (blind to the reviewer) version of the scale translated and adapted by Neto *et al.* (1990) was used.

Instrumental Activities of Daily Living Scale (IADL, Lawton & Brody, 1969). The IADL is a tool that evaluates instrumental daily activities, comprising 8 items: ability to use telephone, shopping, food preparation, housekeeping, laundry, mode of transportation, responsibilities for own medications, ability to handle finances. It is considered without disability if there is no impairment at all or only 1 item is compromised, and the score 9 is applied when the task has never been done. The (blind to the reviewer) version, done in the context of LADIS project, was used (Pantoni *et al.*, 2005).

Time Perspective Assessment

Time Orientation Scale and Time Relation Scale (Mello *et al.*, 2013), adapted from the Adolescent Time Inventory (ATI; Mello & Worrell, 2007), which is now called the Adolescent and Adult Time Inventory (Mello *et al*., 2016). This test was originally developed and validated in studies with adolescents and young adults (Mello *et al*, 2013; Mello *et al.*, 2018), but was more recently also used in studies with older adults (Mello *et al*., 2021).

The Time Orientation Scale evaluates the relative importance given to time dimensions (Mello & Worrell, 2007; Figure 1). Participants are asked to choose one configuration among a set of seven circle configurations. Each configuration has three circles, corresponding to past, present and future and their importance is assigned to the size of the circle. Participants are given the instruction: "*Choose one of the configurations that shows how important the past, the present and the future are for you*."

The Time Relation Scale measures how individuals' perceive time dimensions to be related to each other. Participants have to choose only one configuration among a set of five circle configurations. Participants are given the instructions: "*Choose a configuration that*

shows your opinion about the relations between past, present and future." Each configuration reflects the relationship among time periods with overlapping circles. The original version of the instrument (Mello & Worrell, 2007) comprised only 4 circle configurations. As the previous version did not consider the past-present related, we added this configuration for the first time, with the permission of the authors. For the sake of analysis simplification and comprehensibility, we sorted the 5 configurations (Figure 2) into 3 groups: *unrelated* (configuration 1), *intermediate* (present-future related – configuration 2; past-present related - configuration 3) and *fully related* (linear related – configuration 4; interrelated – configuration 5).

The *Zimbardo Time Perspective Inventory* (ZTPI; Zimbardo & Boyd, 1999) Portuguese version (Ortuño & Gamboa, 2009) was used. This 56-item scale explores the beliefs, preferences and values attached to the experience of the three time dimensions. According to the hedonic value attributed to the time experiences, the scale was organized into 5 factors: *Past Positive*, *Past Negative*, *Future*, *Present Hedonistic* and *Present Fatalistic*. *Past Positive* (9 items) has to do with a warm and sentimental attitude towards the past and is represented by items, such as "*I get nostalgic about my childhood*." *Past Negative* (10 items) reflects a negative and aversive view of the past and is represented by items, such as "*I think about the bad things that have happened to me in the past*." *Future* (13 items) suggests a behaviour dominated by a striving for future goals and rewards and is represented by items, such as "*It upsets me to be late to appointments*." *Present Hedonistic* (15 items) reflects a focus towards present pleasure and a risk-taking attitude and is represented by items, such as "*Taking risks keeps my life from becoming boring*." Finally, *Present Fatalistic* (9 items) reveals a fatalistic, hopeless, helpless attitude toward the future and life and is represented by items, such as "*My life path is controlled by forces I cannot influence*." Items

belonging from *Past Positive*, *Past Negative*, *Future*, *Present Hedonistic* and *Present Fatalistic* factors were presented randomly. Items were rated from 1 (*nothing*) to 5 (*totally*).

Results

Analytic Strategy

Demographic, clinical and neuropsychological data were compared between the two groups, patients with aMCI and controls, with the Student's *t*-test for numerical variables, after checking for normality and homoscedasticity assumptions, and Pearson χ^2 test or Fisher exact test, as appropriate, for categorical variables. Differences in frequency distributions of choices in Time Orientation and Time Relation tests between patients with aMCI and controls were evaluated with the Pearson χ^2 test. The configurations in Time Relation were grouped into unrelated, intermediate and fully related, as mentioned above, and a trend analysis was performed. As a measure of effect size the ϕ value was used. The correlation analysis between Time Relation choices, grouped into unrelated, intermediate and fully related, and the neuropsychological tests scores was performed with Kendall's τ_b correlation. Absolute values of $\tau_b \geq 0.35$ were considered to represent strong associations.

Regarding the ZTPI, items corresponding to each scale were added and then divided by the number of the items performed by each subject, in order to constitute *Past Positive*, *Past Negative*, *Future*, *Present Fatalistic* and *Present Hedonistic* factors scores. In order to verify if significant differences exist between the aMCI group and the control group for the 5 factors scores, an analysis on Time Perspective factors was performed with mixed-design analysis of variance (ANOVA). Patients with aMCI and controls were considered between-subjects effects, while Time Perspective factors (Past Negative, Past Positive, Future, Present Hedonistic and Present Fatalistic) were used to evaluate within-subjects effects. To check differences between the 5 Time Perspective factors, an *a priori* contrast test with the mean

squared error (MSE) from the Repeated Measures ANOVA was conducted. The correlation analyses between Time Perspective factors scores and the neuropsychological tests scores were performed with the Pearson's correlation test.

Statistical analyses were performed using SPSS for Windows (SPSS 19; SPSS Inc., Chicago, Ill). Effects with p values <0.05 were considered statistically significant.

Sample size was estimated from a power analysis using the Power and Precision software (v.4; BioStat; Englewood, NJ). Assuming the proportion of 7% for the responses *Past* or *Past-Present* in the TOS previously reported in older healthy adults (Mello *et al*., 2021), recruitment of 60 participants (30 patients with aMCI and 30 controls) would allow to detect one third of patients with aMCI showing preference towards the past in the TOS, assuming power = 82%, $\alpha = 0.05$, one tailed test.

Preliminary Analyses

Sixty-three participants, 33 controls and 30 patients with aMCI, performed neuropsychological evaluation and an experimental protocol with the Time Orientation and Time Relation circles tests and the ZTPI. There were no differences in age, education, gender and activity/retirement status between the two groups (Table 1).

Regarding neuropsychological characteristics, the aMCI participants had lower MMSE scores, worse performances in cognitive tests, namely memory (Logical Memory A, immediate recall and delayed recall) and executive functions (TMT A and B), and presented more subjective memory complaints (SMC) as well as more depressive (GDS) symptoms than controls (see Table 1). No differences in attentional tests (Digit Span), Clock Drawing Test and in life satisfaction (SWLS) were found between the two groups (Table 1).

[INSERT TABLE 1 HERE]

Primary Analyses

Time Orientation. Patients with aMCI and healthy controls did not choose differently the 7 configurations depicting the relative importance of time dimensions (Figure 1; $\chi^2(6) = 3.114$, $\phi = 0.222$, $p = 0.794$).

[INSERT FIGURE 1 HERE]

Time Relation. Patients with aMCI tended to choose the unrelated configuration 1 more often than the intermediate configurations (present-future related – configuration 2; past-present related - configuration 3) and less often the fully related configurations (linear related – configuration 4; interrelated – configuration 5), as compared to controls (Figure 2; $\chi^2(1)$ for trend $= 7.014$, $\phi = 0.344$, $p = 0.008$).

[INSERT FIGURE 2 HERE]

Relation between Time Relation Performance and Cognitive Functions. Time Relation choices were significantly and strongly correlated with both measures of executive function performance, Trail Making Test B (TMT B) and Digit Span backward (DSB), in patients with aMCI (TMT B: $\tau_b = -0.41$, $p = 0.01$; DSB: $\tau_b = 0.35$, $p = 0.02$) but not in controls (Table 2). This means the better aMCI patients performed in executive tests, the more they tended to view past, present and future dimensions as related. No significant correlations were detected between Time Relation choices and memory performance, depressive symptoms and memory complaints.

[INSERT TABLE 2 HERE]

Zimbardo Time Perspective Inventory. There were no significant differences between patients with aMCI and controls on Time Perspective factors of ZTPI (repeated measures ANOVA $F(1,61) = 0.833$, $p = 0.365$, $\eta^2_p = 0.013$) and no interactions between the diagnostic group and Time Perspective factors (repeated measures ANOVA $F(4,244) = 1.722$, $p = 0.146$, $\eta^2_p = 0.027$). Significant differences were detected in Time Perspective factors (repeated

measures ANOVA, F (4,244) =74.732, p<0.01, η^2_p=0.551), that is, participants scored higher in the *Past Positive* (3.52±0.07) and *Future* (3.38±0.07) factors, followed by the *Present Hedonistic* (2.96±0.09) and then by both the *Present Fatalistic* (2.44±0.10) and the *Past Negative* (2.29±0.09) factors (Table 3).

Although no significant differences were found between patients with aMCI and controls on Time Perspective in the ZTPI, we performed an exploratory analysis to know whether Time Perspective factors might be associated to neuropsychological tests in the whole sample. Significant negative correlations were found between *Present Hedonistic* and executive tests, both TMT A (r=-0.41, p<0.01) and TMT B (r=-0.33, p<0.01), as well as between *Future* and executive tests, both TMT A (r=-0.36, p<0.01) and TMT B (r=-0.41, p<0.01).

[INSERT TABLE 3 HERE]

Discussion

The main finding of this study is that patients with aMCI present differences in Time Relation, that is, they tend to perceive the three time dimensions (past, present and future) as unrelated, as compared to healthy controls. This difference is correlated with deficits in executive functions.

Contrary to the initial hypothesis, patients with aMCI did not show a biased individual preference towards the past, and appraised the relative importance of the three time dimensions similarly as healthy controls in the Time Orientation circles task. We have previously found that patients with aMCI report time passing slower when producing subjective passage of time judgments, as compared to healthy controls (Coelho *et al.*, 2016), but this was not apparently reflected in an unbalanced orientation regarding time dimensions.

Certainly, complex emotional and personality factors are involved in subjective passage of time judgments (Wittmann *et al*., 2015).

Patients with aMCI showed feelings, experiences and values concerning the three time dimensions that are not different from healthy controls, as assessed with the ZTPI. In accordance with our findings, a previous study evaluated four patients with amnesia caused by hippocampal damage and did not find alterations in time perspective using the ZTPI test (Kwan *et al.*, 2013). In the present study, *Past positive* and *Future* dominated the choices of all participants, which is consistent with previous studies reporting that older individuals focus less on negative events of the past (Laureiro-Martinez *et al.*, 2017) and tend to think about the limitations of the future (Carstensen, 2006; Mello, 2019), as an attempt to better manage their remaining lifetime (Barber & Strickland-Hughes, 2019). At this point, it seems fair to say that patients with aMCI did not differ from healthy elders in their attitudes toward the past, present and future.

What appears to change in patients with aMCI, as observed in the Time Relation circles task, is that they tend to perceive the time dimensions as unrelated, whereas healthy old people tend to recognize time dimensions as interrelated (Mello *et al*., 2021). The propensity to connect the time dimensions appears to correspond to a healthy pattern, inasmuch previous studies showed that healthy old people tend to choose interrelated configurations, possibly corresponding to changes in their lives, such as retirement or increasing worries about health prospects (Mello *et al*., 2021). The basis for the difficulty that patients with aMCI showed in perceiving the time dimensions as related was explored by correlation analyses between Time Relation and different neuropsychological variables. The Time Relation choices did not correlate with memory performance, or the subjective impression about memory capabilities, in spite of memory deficits being the cognitive hallmark of patients with aMCI (Ribeiro *et al.*,

2006). Personality factors are known to influence time perspective in young adults (Cottle, 1967; Getsinger, 1975), however in the present study no correlations were found between Time Relation choices and depressive symptoms. Importantly, significant correlations were observed between Time Relation choices and measures of executive functions in patients with aMCI, but not in healthy controls. Such correlations were consistent across several executive functions tests, and were not found for memory tests. In other words, the better the performance in the Trail Making Test B (and marginally significantly in the Trail Making Test A) and in Digit Span backward, the more patients with aMCI tended to choose the related configurations. The fact that these measures of executive functions correlated significantly with Time Relation choices reinforces the importance of these cognitive abilities for the accomplishment of the task. Indeed, recent studies emphasised the presence of executive functions deficits in patients with aMCI, namely in inhibitory and interference control, cognitive control and cognitive flexibility (Chehrehnegar *et al*., 2019; Guarino *et al.*, 2019).

The relationship between Time Relation choices and executive functions deserves further consideration. Following Baddeley's theory, one of the subsystems in the central executive is the episodic buffer, that combines short-term and long-term memory, holding and manipulating a limited amount of information from multiple domains (Baddeley *et al.,* 2011). The episodic buffer integrates this information in an order that is not only spatially arranged but also temporally sequenced (Karlsen *et al*., 2010). Indeed the prefrontal cortex, a brain structure crucially involved in executive functions, plays a critical role in the temporal integration of information (Fuster, 2001) and processing of time (El Haj & Kapogiannis, 2016). We herein speculate that the executive dysfunction observed in patients with aMCI might disturb the perception of time, affecting the connections among past, present and future

time dimensions. This assumption should obviously be explored and confirmed in future studies. A further observation from the present study strengthens the argument that time perspective and executive functions are related. Although no significant differences were found between patients with aMCI and controls on Time Perspective in the ZTPI, we observed that participants who performed better in executive tests tended to report preferences on present pleasure (*Present Hedonistic*) and choose striving for future goals (*Future*).

As far as we know, this is the first study to assess time perspective in aMCI. Previous studies in time perception found differences between patients with aMCI and healthy controls in temporal *succession* (Gillis et al., 2013) and *duration*, specifically in passage of time judgments (Coelho *et al*., 2016). The present study expands these findings, showing that patients with aMCI have alterations in time *perspective*, namely in perceiving the interconnection between the three time dimensions, as evidenced when making Time Relations choices. As strengths, it used instruments that evaluate the three time dimensions at the same time, and considered different aspects of time perspective. A limitation of the study is the relatively small sample size. Also, more extensive testing of executive functions would be desirable. Although patients with aMCI are generally at an initial stage of AD, this was not confirmed with positive AD biomarkers.

In conclusion, patients with aMCI ascribe the relative importance and show feelings, experiences and values concerning the three time dimensions in a similar way as healthy controls do, but they have difficulty in relating the time dimensions, probably as consequence of deficits in executive functions. This result is supported by a prior study (Mello et al. 2021) that showed healthy older adults were more likely to perceive time periods as related to one another and less likely to perceive time periods as unrelated to one another. These findings

are certainly a preliminary insight into the temporal relationships in patients with aMCI, further exploration and replication of this research in independent samples being needed.

The observation that adults with aMCI may have limited understanding for how their current behaviours are related to both their past and future might have implications for adherence to therapies or medicine. Older people face important life decisions in health and finance at end of their lives (Sproten et al., 2010). Time dimensions interconnection corresponds to a healthy pattern in old age, in the sense that elders can learn with past mistakes, associate them with their current situation and be open about the future (Sword et al., 2015). Therapies such as Time Perspective Therapy can help patients with MCI to build links between the different time dimensions, for instance encouraging them to perceive the future as not limited (Bitti et al., 2015) and promoting pro-social behaviours and well-being (Kazakina, 2015).

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Table 1. Demographic and Neuropsychological Characteristics

	aMCI (n=30)	CONTROL (n=33)	*p* Value
AGE, years, mean (SD)	75.4 (7.6)	74.2 (8.1)	0.52 [a]
EDUCATION, years, mean (SD)	9.8 (4.2)	11.7 (4.4)	0.09 [a]
GENDER, female/male, n	20/10	21/12	0.80 [b]
ACTIVITY, employed/retired, n	1/29	5/28	0.20 [c]
MINI MENTAL STATE EXAMINATION, mean (SD)	26.4 (2.1)	29.0 (1.0)	**<0.01** [a]
DIGIT SPAN FORWARD, mean (SD)	5.8 (0.6)	5.6 (1.0)	0.24 [a]
DIGIT SPAN BACKWARD, mean (SD)	3.9 (1.1)	3.9 (1.0)	0.93 [a]
LOGICAL MEMORY A (immediate recall), mean (SD)	5.3 (3.2)	13.9 (2.8)	**<0.01** [a]
LOGICAL MEMORY A (delayed recall), mean (SD)	3.2 (3.0)	14.6 (3.4)	**<0.01** [a]
TRAIL MAKING TEST A, seconds, mean (SD)	90.8 (46.5)	59.2 (28.4)	**<0.01** [a]
TRAIL MAKING TEST B, seconds, mean (SD)	264.6 (98.9)	169.6 (98.5)	**<0.01** [a]
CLOCK DRAWING TEST, mean (SD)	2.2 (0.8)	2.5 (0.9)	0.14 [a]
SUBJECTIVE MEMORY COMPLAINTS, mean (SD)	10.8 (3.5)	5.5 (2.5)	**<0.01** [a]
GERIATRIC DEPRESSION SCALE, mean (SD)	4.8 (2.3)	2.3 (2.0)	**<0.01** [a]
SATISFACTION WITH LIFE SCALE, mean (SD)	22.3 (6.3)	23.8 (5.8)	0.35 [a]

Abbreviations: aMCI, amnestic Mild Cognitive Impairment; SD, standard deviation.

Statistically significant values are shown in bold.

[a] Independent samples Student's *t* test.

[b] Pearson χ^2 test.

[c] Fisher Exact test.

Table 2. Correlations between Time Relation and Neuropsychological Variables

		TIME RELATION	
LOGICAL MEMORY A (immediate recall)	aMCI	τ_b =0.14	*p*=0.35
	CONTROL	τ_b =0.05	*p* =0.72
LOGICAL MEMORY A (delayed recall)	aMCI	τ_b =0.10	*p* =0.52
	CONTROL	τ_b =-0.17	*p* =0.25
SUBJECTIVE MEMORY COMPLAINTS	aMCI	τ_b <0.01	*p* =0.98
	CONTROL	τ_b <0.01	*p* =0.99
GERIATRIC DEPRESSION SCALE	aMCI	τ_b <0.01	*p* =0.95
	CONTROL	τ_b <0.01	*p* =0.99
TRAIL MAKING TEST A Time	aMCI	τ_b =-0.30	*p* =0.05
	CONTROL	τ_b =0.12	*p* =0.39
TRAIL MAKING TEST B Time	aMCI	τ_b =**-0.41**	***p* =0.01**
	CONTROL	τ_b =0.13	*p* =0.36
DIGIT SPAN FORWARD	aMCI	τ_b =0.31	*p* =0.06
	CONTROL	τ_b =0.01	*p* =0.95
DIGIT SPAN BACKWARD	aMCI	τ_b =**0.35**	***p* =0.02**
	CONTROL	τ_b =-0.02	*p* =0.89

Abbreviations: τ_b, Kendall's τ_b correlation coefficient.

Statistically significant values are shown in bold.

No significant correlations were found between Time Relation choices and neuropsychological variables in the Control group. Significant ($p<0.05$) and strong (τ_b absolute value $\geq$ 0.35) correlations were found in aMCI patients between Time Relation choices and executive functions measures, namely Trail Making Test B and Digit Span backward. This means that patients with aMCI who performed better in the Trail Making Test B (spent less time) and in Digit Span Backward (produced more items in reversed order) tended to view past, present and future dimensions as related.

Table 3. Time Perspective Factors

	aMCI (n=30)	CONTROL (n=33)	ALL (n=63)
ZTPI_Past_Negative, mean (SD)	2.2 (0.7)	2.3 (0.7)	2.3 (0.7)
ZTPI_Present_Hedonistic, mean (SD)	2.8 (0.7)	3.1 (0.6)	3.0 (0.7)
ZTPI_Future, mean (SD)	3.3 (0.5)	3.5 (0.5)	3.4 (0.5)
ZTPI_Past_Positive, mean (SD)	3.5 (0.6)	3.6 (0.5)	3.5 (0.6)
ZTPI_Present_Fatalistic, mean (SD)	2.5 (0.8)	2.4 (0.8)	2.4 (0.8)

Abbreviations: aMCI, amnestic Mild Cognitive Impairment; ZTPI, Zimbardo Time Perspective Inventory; SD, standard deviation.

The analysis on Time Perspective factors, performed with repeated-measures analysis of variance (ANOVA), showed no significant differences between aMCI patients and controls, see text for details.

Figure Legends:

Figure 1

Absolute frequencies of configuration choices on Time Orientation in aMCI patients and controls. Each configuration (Config.) is displayed of the left side of the Figure and it is composed by three circles, corresponding to the past (left circle, PA), the present (middle circle, PR) and the future (right circle, FU). The degree of importance is related to the size of the circle (e.g., the importance of largest circles is higher). Differences in frequency distributions of choices in the Time Orientation test between aMCI patients and controls were evaluated with the Pearson χ^2 test. Patients with aMCI and healthy controls did not choose differently the 7 configurations depicting the relative importance of time dimensions.

Figure 2

Absolute frequencies of configuration choices on Time Relation in aMCI patients and controls. Each configuration (Config.) is displayed of the left side of the Figure and it is composed by three circles differently related, corresponding to the past (PA), the present (PR) and the future (FU). Differences in frequency distributions of choices in the Time Relation test between aMCI patients and controls were evaluated with the Pearson χ^2 test for trend. Patients with aMCI tended to choose more often the unrelated configuration 1 than the intermediate configurations 2 and 3, and less often the fully related configurations 4 and 5, as compared to controls.

Figure 1 - Time Orientation Configuration Frequencies for aMCI Patients and the Control Group.

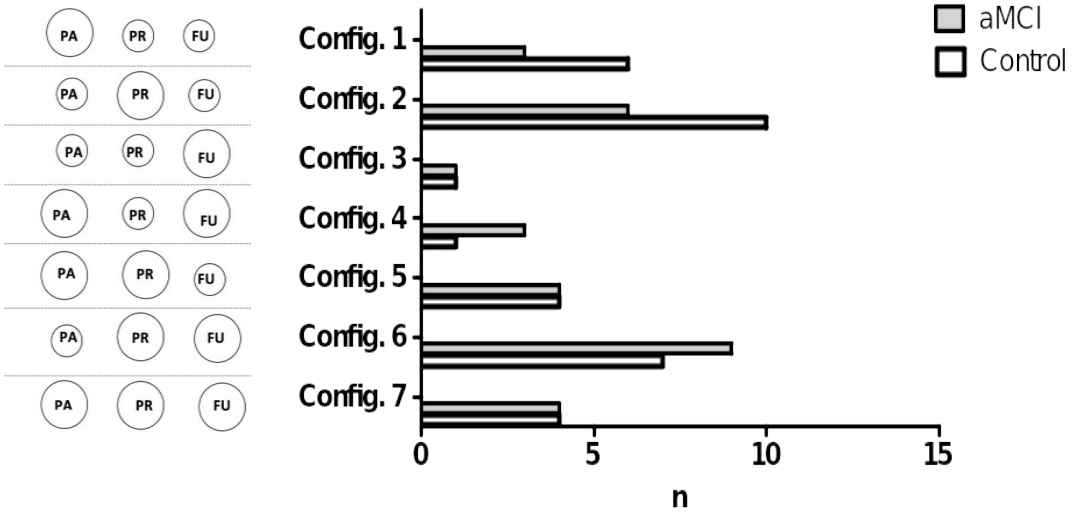

Figure 2 - Time Relation