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Time perspective and amnestic mild cognitive impairment

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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 thirty-three 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.

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 emphasized (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

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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-Feshki, 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, Tobin, & Rondi-Reig, 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 & Ivry, 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, Riemer, Wolbers, & Van Rijn, 2019; Mioni, Meligrana, Perini, Marcon, & Stablum, 2019; Mioni, Román-Caballero, Clerici, & Capizzi, 2021; Rueda & Schmitter-Edgecombe, 2009), 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, Quinn, Phillips, & Hampstead, 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, present, and future influence decisions, goal setting, and emotions and motivate human behaviour (Carstensen, Isaacowitz, & Charles, 1999; Janeiro, 2012; 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 towards the past, present, and future. Other dimensions of time perspective include *Time Orientation*, the preference towards a particular time period (Cottle, 1967; Mello & Worrell, 2015; Nuttin & Lens, 1985), and *Time Relation*, the perceived relationships among the past, present, and future (Cottle, 1967; Mello & Worrell, 2015). The Time Orientation Scale (TOS) and Time Relation Scale (TRS) were designed to measure these time perspective dimensions (Mello, Finan, & Worrell, 2013). The TOS evaluates the dominance of one or more time dimensions over the others and the TRS addresses the relationships among the past, present, and 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, 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, Barber, Vasilenko, Chandler, & Howell, 2021; Mello et al., 2013). 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, and 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, Edwards, & Lambert, 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, Carelli, & Ledzińska, 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, de Mendonça, & Guerreiro, 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, Rudolf, Gutierrez, & Winker, 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 hypothesized 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. Furthermore, 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, Memoclínica, in Lisbon, 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 Lisbon. The study was approved by the ethics committee of Faculty of Medicine/Santa Maria Hospital in Lisbon, 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 Portuguese 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 Portuguese population (see below); and (4) no impairment or minimal impairment in activities of daily living determined by the Instrumental Activities of Daily Living Scale (IADL), that is, 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 Portuguese population; and (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 and 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; and (6) sensory deficits likely to interfere with assessment.

Measures

Neuropsychological evaluation

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

Logical Memory Test 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 Portuguese population. Participants with Logical Memory A (immediate or delayed recall) below education and age adjusted values for the Portuguese 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 who suffered from aMCI (Palmer, Fratiglioni, & Winblad, 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 Portuguese 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, Jonker, Hooijer, & Lindeboom, 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 Portuguese version of the test adapted from Ginó et al. (2008) was used.

Geriatric Depression Scale (GDS, Yesavage et al., 1983). The GDS is a questionnaire that evaluates the existence and the degree of depressive symptomatology. The version with 15 items was chosen (Yesavage & Sheikh, 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 Portuguese version adapted from Barreto, Leuschner, Santos, and Sobral (2008) was used.

Satisfaction With Life Scale (SWLS, Diener, Emmons, Larsen, & Griffin, 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 Portuguese version of the scale translated and adapted by Neto, Barros, and Barros (1990) was used.

Instrumental Activities of Daily Living Scale (IADL, Lawton & Brody, 1969). The IADL is a tool that evaluates instrumental daily activities, comprising eight items: ability to use telephone, shopping, food preparation, housekeeping, laundry, mode of transportation, responsibilities for own medications, and ability to handle finances. It is considered without disability if there is no impairment at all or only one item is compromised, and the score 9 is applied when the task has never been done. The Portuguese 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, Olapido, Paoloni, & Worrell, 2018), but was more recently also used in studies with older adults (Mello et al., 2021).

The TOS 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

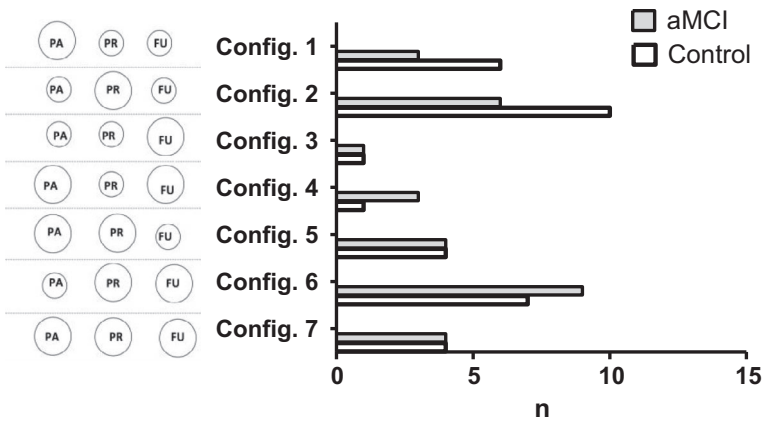

Figure 1. Time Orientation Configuration Frequencies for aMCI Patients and the Control Group. Absolute frequencies of configuration choices on Time Orientation in aMCI patients and controls. Each configuration (Config.) is displayed on the left side of the Figure and it is composed by three circles, corresponding to the past (left circle, PA), present (middle circle, PR), and 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 seven configurations depicting the relative importance of time dimensions.

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 four 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 five configurations (Figure 2) into three groups: *unrelated* (configuration 1), *intermediate* (present–future related – configuration 2; and past–present related – configuration 3), and *fully related* (linear related – configuration 4; and interrelated – configuration 5).

The *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 five 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 towards the future and life and is represented by items, such as

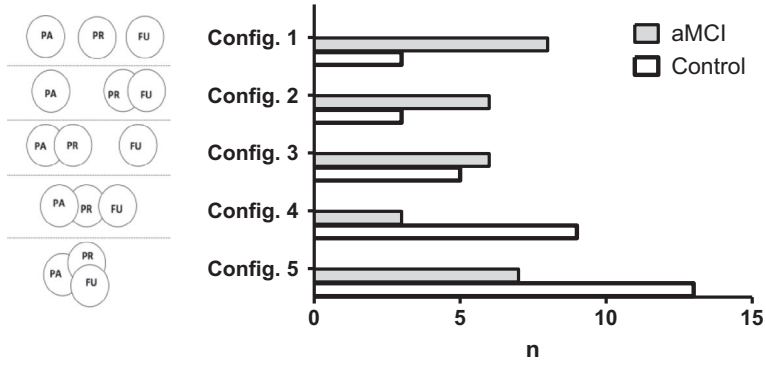

Figure 2. Time relation. Absolute frequencies of configuration choices on Time Relation in aMCI patients and controls. Each configuration (Config.) is displayed on the left side of the Figure and it is composed of three circles differently related, corresponding to the past (PA), present (PR), and future (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.

'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 five 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 five 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 IBM SPSS Statistics 26 for Windows (IBM Corp., Armonk, NY). Effects with p values $< .05$ 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%, $\alpha = .05$, one-tailed test.

Preliminary analyses

A total of 63 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,

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)	.52[a]
EDUCATION, years, mean (*SD*)	9.8 (4.2)	11.7 (4.4)	.09[a]
GENDER, female/male, *n*	20/10	21/12	.80[b]
ACTIVITY, employed/retired, *n*	1/29	5/28	.20[c]
MINI-MENTAL STATE EXAMINATION, mean (*SD*)	26.4 (2.1)	29.0 (1.0)	**<.01**[a]
DIGIT SPAN FORWARD, mean (*SD*)	5.8 (0.6)	5.6 (1.0)	.24[a]
DIGIT SPAN BACKWARD, mean (*SD*)	3.9 (1.1)	3.9 (1.0)	.93[a]
LOGICAL MEMORY A (immediate recall), mean (*SD*)	5.3 (3.2)	13.9 (2.8)	**<.01**[a]
LOGICAL MEMORY A (delayed recall), mean (*SD*)	3.2 (3.0)	14.6 (3.4)	**<.01**[a]
TRAIL MAKING TEST A, seconds, mean (*SD*)	90.8 (46.5)	59.2 (28.4)	**<.01**[a]
TRAIL MAKING TEST B, seconds, mean (*SD*)	264.6 (98.9)	169.6 (98.5)	**<.01**[a]
CLOCK DRAWING TEST, mean (*SD*)	2.2 (0.8)	2.5 (0.9)	.14[a]
SUBJECTIVE MEMORY COMPLAINTS, mean (*SD*)	10.8 (3.5)	5.5 (2.5)	**<.01**[a]
GERIATRIC DEPRESSION SCALE, mean (*SD*)	4.8 (2.3)	2.3 (2.0)	**<.01**[a]
SATISFACTION WITH LIFE SCALE, mean (*SD*)	22.3 (6.3)	23.8 (5.8)	.35[a]

Note. 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.

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 life satisfaction (SWLS) were found between the two groups (Table 1).

Primary analyses

Time orientation

Patients with aMCI and healthy controls did not choose differently the seven configurations depicting the relative importance of time dimensions (Figure 1; $\chi^2(6) = 3.114, \phi = 0.222, p = .794$).

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, $\phi = 0.344, p = .008$).

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: $\tau_b = -0.41, p = .01$; DSB: $\tau_b = 0.35, p = .02$) 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.

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 = .365, η_p^2 = 0.013) and no interactions between the diagnostic group and Time Perspective factors (repeated measures ANOVA F (4,244) = 1.722, p = .146, η_p^2 = 0.027). Significant differences were detected in Time Perspective factors (repeated measures ANOVA, F

Table 2. Correlations between time relation and neuropsychological variables

Time relation		
	τ_b	p
Logical memory A (immediate recall)		
aMCI	0.14	.35
Control	0.05	.72
Logical memory A (delayed recall)		
aMCI	0.10	.52
Control	−0.17	.25
Subjective memory complaints		
aMCI	<0.01	.98
Control	<0.01	.99
Geriatric depression scale		
aMCI	<0.01	.95
Control	<0.01	.99
Trail making test A time		
aMCI	−0.30	.05
Control	0.12	.39
Trail making test B time		
aMCI	**-0.41**	**.01**
Control	0.13	.36
Digit span forward		
aMCI	0.31	.06
Control	0.01	.95
Digit span backward		
aMCI	**0.35**	**.02**
Control	−0.02	.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 ($p < .05$) and strong (τ_b absolute value ≥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.

(4,244) = 74.732, $p < .01$, $\eta_p^2 = 0.551$), 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 with neuropsychological tests in the whole sample. Significant negative correlations were found between *Present Hedonistic* and executive tests, both TMT A ($r = -.41$, $p < .01$) and TMT B ($r = -.33$, $p < .01$), as well as between *Future* and executive tests, both TMT A ($r = -.36$, $p < .01$) and TMT B ($r = -.41$, $p < .01$).

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, Craver, Green, Myerson, & Rosenbaum, 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, Trujillo, & Unda, 2017) and tend to think about the limitations of the future (Carstensen, 2006; Mello, 2019), as an attempt to better manage their remaining

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)

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

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 towards 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 emphasized 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, Forte, Giovannoli, & Casagrande, 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, Allen, & Hitch, 2011). The episodic buffer integrates this information in an order that is not only spatially arranged but also temporally sequenced (Karlsen, Allen, Baddeley, & Hitch, 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 on 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, Diener, Fiebach, & Schwieren, 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, Sword, & Brunskill, 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, Zambianchi, & Bitner, 2015) and promoting pro-social behaviours and well-being (Kazakina, 2015).

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Conflicts of interest

All authors declare no conflict of interest.

Author contribution

Sara Coelho: Conceptualization (equal); Formal analysis (equal); Investigation (equal); Writing – original draft (equal). **Alexandre de Mendonça:** Conceptualization (equal); Methodology (equal); Supervision (equal); Writing – original draft (equal). **Joao Maroco:** Formal analysis (equal); Methodology (equal). **Sandra Cardoso:** Data curation (equal); Formal analysis (equal). **Zena Mello:** Supervision (equal). **Manuela Guerreiro:** Conceptualization (equal); Investigation (equal); Methodology (equal); Supervision (equal).

Ethics approval

This study was approved by the ethics committee of Faculty of Medicine/Santa Maria Hospital in Lisbon.

Consent to participate

All participants gave their written consent.

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