

# Subjective experience of time in dementia with Lewy bodies during COVID-19 lockdown

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## Research Article

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# Abstract

Dementia with Lewy bodies (DLB) is a neurodegenerative disease characterized by cognitive, behavioral and motor symptoms and has a more challenging clinical management and poorer prognosis respect to other forms of dementia. The experience of lockdown leads to negative psychological outcomes for fragile people such as elderly with dementia, particularly for DLB, causing a worsening of cognitive and neuropsychiatric symptoms. An individual's feeling of time passage is strongly related to her cognitive and emotional state. We therefore assessed the subjective experience of the passage of time for present and past time intervals (Subjective Time Questionnaire, STQ) during the lockdown due to coronavirus disease (COVID-19) in 23 patients with DLB (18 of which were re-tested in a post-lockdown period) and compared their experience with that of 21 caregivers with similar age and 46 younger university students. Patients showed a significantly slower perception of time and also reported feeling less time pressure. We argue that these alterations might be related to the distinctive features of DLB and their exacerbation recorded by the patients' caregivers during the period of lockdown, though our results show that the patients' experience of time passage in a post-lockdown period remained similarly slow. Overall, we show an impairment of the subjective perception of time passage in DLB tested during the COVID-19 lockdown.

## Introduction

The notion of time represents a fundamental component of human experience (Paton & Buonomano, 2018). The temporal structure of surrounding stimuli defines the way information is perceived, experienced, and remembered (Merchant et al., 2013) and time-dependent cognition enables us to interact with an ever-changing environment (Finnerty et al., 2015).

The concept of subjective time refers to the way individuals perceive and evaluate their personal time during their lifespan (Gabrian et al., 2017) and one of its primary dimensions is time awareness, which can be defined as the subjective impression of time as moving quickly or slowly (Wittman & Lehnhoff, 2005). Unlike physical time, the subjective experience of time passage can be affected by variations in external stimulation (Droit-Volet & Meck, 2007; Zakay & Block, 1997) and by the individual's emotional and cognitive state (Droit-Volet, 2013; Droit-Volet & Gil, 2009; Jokic et al., 2018; Teixeira et al., 2013; Wittman, 2009). In particular, evidence from Wearden and colleagues (2014) suggests that passage of time judgments (POTJs, i.e., judgements of how fast or slowly time seems to pass relative to "normal") are related to hedonic variables, with positive states (enjoyment, excitement, liking, engagement) being associated with faster POTJs and negative ones (boredom, sadness, annoyance, fatigue) with slower POTJs (Wearden, 2015).

There is no human clinical condition that can be defined solely as a disorder of timing and time perception *per se*, although distortions and perturbations in timing ability are present in many populations and may be associated with different developmental, cognitive and behavioral profiles (Allman & Meck, 2011). As a matter of fact, individuals with psychiatric or neurologic conditions often exhibit difficulty in

perceiving and organizing time, frequently due to disorders on attention, memory and related to neurotransmitters dysregulation affecting dopamine and acetylcholine systems (Marinho et al., 2017).

Amongst the many existing neurodegenerative disorders, dementia with Lewy bodies (DLB) stands out for its challenging management and poorer prognosis (Mueller et al., 2017) due to the mixture of neuropsychiatric, motor and autonomic symptoms. Compared with Alzheimer's Disease (AD), a diagnosis of DLB is associated with steeper cognitive decline (Kramberger et al., 2017), earlier admission in nursing homes (Rongve et al., 2013), poorer quality of life (Bostrom et al., 2007), greater caregiver burden (Svendsboe et al., 2016) and increased mortality (Price et al., 2017; Williams et al., 2006).

So far, timing abilities have not yet been extensively investigated in DLB patients. Only two studies have been conducted. The first is a pilot study by Lesimple et al. (2016) which showed impairment in the perception of rhythmic variations and verbal time estimation in 7 patients with DLB as compared with healthy controls. The other study (Matar et al., 2019) tested 25 patients with probable DLB and 14 older controls in a simple time perception paradigm, finding altered temporal processing of target intervals that correlated with cognitive fluctuations in the DLB group. To the best of our knowledge, the dimension of time awareness and POTJs have never been examined in people with DLB.

During the implementation of the present study, Italy was undergoing a public health crisis due to the global epidemic from coronavirus disease (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2), that started in December 2019 in the city of Wuhan, China. Starting from March 10<sup>th</sup> 2020, the Italian Government issued a series of decrees that imposed lockdown to all the citizens in the country until May 3<sup>rd</sup>. Lockdown is a period of restriction of movement of people, who are confined to their homes and socially isolated. Lockdown is a severe measure imposed by governments as an attempt to reduce or block the chain of transmission of a contagious disease and contain the spread of infections. Although necessary, this measure and similar ones such as quarantine, are often lived as an unpleasant experience that brings along negative outcomes in terms of physical and mental health for those who undergo it (Brooks et al., 2020). Fear, anxiety, loss of control and a feeling of being trapped are among the most commonly reported effects (Rubin & Wessely, 2020), but also symptoms of post-traumatic stress disorder and suicides have been observed (Brooks et al., 2020).

Furthermore, people with mental health conditions could be markedly more susceptible to the emotional responses triggered by the pandemic and by the experience of lockdown, with consequent worsening of already existing neuropsychiatric symptoms or onset of new behavioural disorders because of a high susceptibility to stress compared with general population (Yao et al., 2020). Lastly, it might become unfeasible for these people to attend their regular visits due to the restrictions on movement (Yao et al., 2020).

It has been shown that patients with DLB, given their significantly disabling clinical profile, might be particularly vulnerable to the psychological outcomes of the pandemic, leading to a worsening of their symptoms and of their caregivers' burden (Cagnin et al., 2020; Migliaccio & Bouzigues, 2020). In general,

apathy, agitation and anxiety are the most frequently reported worsening symptoms during quarantine in patients with dementia (Simonetti et al., 2020), while in the specific case of DLB patients an increased risk of worsening hallucinations and sleep disorder has been observed (Cagnin et al., 2020). Lockdown and quarantine may be indeed considered as ecological models of the effects of deprivation of multidimensional stimulation, leading to a global down-regulation of cognitive, physical and emotional domains, with increased apathy as one of its main manifestations (Cagnin et al., 2020; Simonetti et al., 2020).

In this context, since the sense of time is determined by an intricate relationship between cognitive functions and temporary emotional states (Wittman, 2009), it is likely that the subjective perception of time will be particularly impaired in patients with DLB during the COVID-19 pandemic, due to the combined effect of their clinical condition and of the experience of lockdown.

Starting from these assumptions, the main goal of this study is to describe the subjective experience of time passage in a group of patients with a diagnosis of probable DLB examined during the period of lockdown from COVID-19, with the expectation to find an altered perception of time in comparison with healthy controls of similar age. In order to do so, we employed the Subjective Time Questionnaire (STQ; Wittman & Lehnhoff, 2005), a tool that assesses how the passage of time is typically experienced in everyday life and how quickly past time intervals are judged to have passed (Mioni et al., 2020), but also the tendency to perceive time at disposal either as scarce and restricted or abundant and dilated. The scores obtained by the patients were also compared with the ones obtained by two other groups, namely caregivers of the same patients (thus with a similar age and sharing the same environment) and younger university students. This was accomplished to isolate and verify a potential differential effect on the subjective perception of time passage of these three separate conditions. Furthermore, in order to ascertain the influence of lockdown on the subjective perception of time in healthy individuals, we compared the STQ scores of the groups of caregivers and younger students with the ones obtained by a group of younger and older people that were examined in a time period prior to the lockdown. We also re-interviewed the majority of the same group of DLB patients in a post-lockdown period: this was done to verify if a reduction in the restrictions imposed by the lockdown would be accompanied by a decreased impairment in the subjective perception of time.

Based on previous findings (Wearden, 2015), the leading hypothesis was that the negative states induced by the experience of lockdown would cause a subjective slowing of the perception of time passage in all groups, and that this would be especially true for the DLB group due to a maladaptation to environmental changes and a higher susceptibility to stress.

## **Method**

### **Participants**

Ninety individuals participated in the present study: 23 diagnosed with probable DLB according to updated McKeith criteria (2017), selected among the patients who refer to the outpatient clinics for

memory disorders of the neurology department of Padua's Hospital; 21 healthy caregivers chosen from the family members who are mostly engaged in the care of the recruited patients; 46 younger people recruited among Padova University students. Three patients and 4 caregivers that were initially screened did not join the research for reasons of indisposition, refusal, or severity of deterioration incompatible with the administration of the questionnaire. Each patient has a recent cognitive screening (MMSE < 6 months) certifying the existence of an ongoing cognitive impairment (mean MMSE raw score = 25.26 ± 3.03 SD). Furthermore, we extracted the questionnaires of 46 younger adults and 20 older adults from a dataset that was collected online in 2016 (a period prior to COVID-19 and lockdown), and the STQ was re-administered to 18 out of the initially interviewed 23 DLB patients (5 of which were indisposed to participate again) in a post-lockdown period, for a total number of 174 questionnaires examined.

The demographic characteristics of the recruited samples are presented in Table 1.

	<b>DLB</b> <i>n</i> = 23 ( <i>M</i> ± <i>SD</i> )	<b>Caregivers</b> <i>n</i> = 21 ( <i>M</i> ± <i>SD</i> )	<b>Younger</b> <i>n</i> = 46 ( <i>M</i> ± <i>SD</i> )	<b>Younger- PRE</b> <i>n</i> = 46 ( <i>M</i> ± <i>SD</i> )	<b>Older-PRE</b> <i>n</i> = 20 ( <i>M</i> ± <i>SD</i> )	<b>DLB-POST</b> <i>n</i> = 18 ( <i>M</i> ± <i>SD</i> )
<b>Age</b>	75.91 ± 5.92	65.24 ± 10.89	23.35 ± 1.46	23.37 ± 1.40	64.75 ± 10.94	76.39 ± 6.06
<b>Education</b>	10.78 ± 4.17	10.95 ± 3.63	16.61 ± 1.89	16.52 ± 1.43	14.70 ± 2.83	10.22 ± 4.04
<b>Gender</b>	m = 17 (73.9%)	m = 4 (19%)	m = 23 (50%)	m = 23 (50%)	m = 4 (20%)	m = 13 (72.2%)
<b>MMSE score</b>	25.26 ± 3.03	N.A.	N.A.	N.A.	N.A.	25.83 ± 2.98

Table 1: demographic characteristics of the samples

## Procedure

After obtaining a preliminary verbal informed consent, an experimenter interviewed each participant by telephone call. The first run of telephone interviews was carried out in the timespan between 04/15/2020 and 04/30/2020, a period in which all Italian citizens were living under the restrictive lockdown measures, while the second run (involving the DLB group only) was accomplished between 07/06/2020 and 07/10/2020, two months after the end of the lockdown. Each volunteer underwent the telephone

administration of the STQ, which was filled out in real time by an examiner and requested an average time of ten minutes per participant. The study was approved by the Ethics Committee of Padua's Hospital.

## Materials

In this study, we used a shortened Italian version of the "Subjective Time Questionnaire" (STQ), a tool developed by Wittman and Lehnhoff (2005) for the assessment of the individual experience of time through the analysis of personal judgments on the passage of time.

The questionnaire is composed by two groups of items to be answered on Likert scale:

1) "Personal Time Experience of Present and Past". This part includes items related to the daily experience of the passage of time and retrospective evaluations of past time intervals, to which respondents are required to answer on a five-anchors Likert scale ranging from -2 = "very slowly" to +2 = "very fast" (Mioni et al., 2020). The two questions covering the perception of present time ("How fast does time usually pass for you?" and "How fast do you expect the next hour to pass?") differ in that the former reflects a view of the passage of time in general, while the latter represents a more transient and state-like momentary perception of time. These two questions are collapsed to form the STQ-present index. The second set of items, which require retrospective judgments of long intervals and past life periods, includes four questions that investigate how fast last week, month, year, and 10 years passed for the individual. In the original version of the questionnaire, the mean value of these four judgements forms the STQ-past index (Mioni et al., 2020). For this research, though, we agreed on setting a distinction between two indices in order to differentiate the subjective perception of recent past time lived under lockdown restrictions (STQ-lockdown, formed by items 3 "How fast did the previous week pass for you?" and 4 "How fast did the previous month pass for you?") from the perception of more remote past intervals lived in "normal" life conditions (STQ-past, formed by items 5 "How fast did the previous year pass for you?" and 6 "How fast did the previous 10 years pass for you?"). The original version of the questionnaire also includes four questions related to the subjective perception of time of the periods of childhood, adolescence, young adulthood and adulthood that have been excluded from this research, since it is a kind of representation that would be difficult to achieve by patients with DLB and because the groups of younger adults could not respond to the items related to adulthood.

2) "Statements on Subjective Time Experience". This part consists of statements on the subjective experience of the time about which respondents must express their degree of agreement on a five-anchors Likert scale ranging from 1 = "strong rejection" to 5 = "strong approval". These ten items are balanced between statements that refer either to a feeling of compression/scarcity of time (e.g., "I often feel time is running out"), forming the Time Pressure index, or to a feeling of expansion/abundance of time (e.g., "I often think that time just does not want to pass"), forming the complementary Time Expansion index. The original version of the questionnaire also includes six metaphors that describe time

passage either as fast (e.g., “Time is a speeding train) or slow (e.g., “Time is a quiet, motionless sea”). These items were excluded from the present study as they are of little relevance to our purposes, but also because they may not be fully understood by the group of DLB patients.

The version of the STQ (both in English and Italian) used for this work is shown in the Appendix.

## Statistics

Statistical analyses were performed using the open-source software JASP (version 0.12.2; <https://jasp-stats.org>). Demographic characteristics and STQ scores were confronted between groups using the Mann-Whitney non-parametric U test for independent samples. We also calculated the Pearson correlation index ( $r$ ) to test the existence of a possible relationship between the MMSE scores and the values of the STQ indices in the DLB group. Statistical significance was set for  $p$  values  $< 0.05$ .

## Results

### Demographic features

Performed analyses revealed heterogeneous samples in terms of demographic features (see Table 2). Patients with DLB, when compared with their caregivers, are on average older and stand out for their significantly greater number of male members. Healthy younger participants present a markedly higher education level compared with DLB and caregivers’ groups, but also a gender distribution that is scarcely comparable to that of caregivers, where female sex predominates. Conversely, since they were selected *ad hoc* from an already acquired database, younger and older participants that were interviewed before the epidemic present mostly similar demographic characteristics to the groups of younger controls and caregivers that were tested during the period of lockdown. Lastly, DLB and DLB-POST groups share very similar demographic characteristics, being mostly composed by the same members (apart from those patients lost due to attrition).

	DLB vs Caregivers	DLB vs Younger	Caregivers vs Younger	Younger vs Younger-PRE	Caregivers vs Older-PRE	DLB vs DLB-POST
<b>Age</b>	<b>&lt; 0.001</b>	<b>&lt; 0.001</b>	<b>&lt; 0.001</b>	0.997	0.896	0.772
<b>Education</b>	0.952	<b>&lt; 0.001</b>	<b>&lt; 0.001</b>	0.168	<b>0.001</b>	0.757
<b>Gender</b>	<b>&lt; 0.001</b>	0.061	<b>0.018</b>	1.000	0.955	0.918

Table 2: Comparison of demographic characteristics with Mann-Whitney U test. Bold values show significant results ( $p < .05$ ).

## Subjective experience of time

The median (*Mdn*) and inter-quartile range (*IQR*) of the scores achieved by the recruited samples on the single items and indices of the STQ are reported in the Supplementary Material, Table A. Table B shows the *p* values obtained from the comparison between groups with a Mann-Whitney U test. Figure 1 displays the distribution of the scores obtained by our samples on the STQ indices.

## DLB vs Caregivers

Statistically significant differences between the two groups were found on the STQ-present index (*Mdn* DLB = 0.00; *Mdn* caregivers = 1.00;  $U = 328.5$ ;  $p = 0.038$ ), with an observed subjective slowing of time perception in the DLB patients compared with their caregivers. The two groups differ only mildly in the perception of recent past time (STQ-lockdown; *Mdn* DLB = 0.00; *Mdn* caregivers = 1.00;  $U = 314.5$ ;  $p = 0.081$ ) and the same goes for remote past periods (STQ-past; *Mdn* DLB = 0.50; *Mdn* caregivers = 1.00;  $U = 319.5$ ;  $p = 0.062$ ).

Time Pressure index score was found to be significantly lower in the DLB group compared with the caregivers (*Mdn* DLB = 2.80; *Mdn* caregivers = 3.40;  $U = 331$ ;  $p = 0.036$ ). Therefore, during COVID-19 lockdown, patients with DLB generally tend to report a slower subjective experience of time than caregivers, while the latter perceive greater time pressure and less time at disposal.

## DLB vs Younger

Compared with younger students, DLB patients obtained significantly lower scores on STQ-present index (*Mdn* DLB = 0.00; *Mdn* younger = 0.75;  $U = 313$ ;  $p = 0.005$ ). This result shows a significantly slower perception of present time in patients with DLB than in younger people during lockdown. Based on STQ-lockdown index scores (*Mdn* DLB = 0.00; *Mdn* younger = 1.00;  $U = 352$ ;  $p = 0.023$ ), the DLB group also exhibits a slowed subjective experience of recent past time lived under lockdown restrictions compared with the group of younger. Conversely, no significant differences were found between the two groups on median STQ-past index scores, suggesting a similar subjective time perception of remote past periods.

As for the “Statements on Subjective Time Experience” subscale, the group of patients obtained lower scores than the younger on Time Pressure index (*Mdn* DLB = 2.80; *Mdn* younger = 3.80;  $U = 198$ ;  $p =$

0.00003). Therefore, DLB patients during lockdown show an experience of time pressure and a sense of scarcity of time available that are significantly lower than those observed in the group of students under lockdown. On the other hand, no significant differences were found between DLB patients and younger controls in the set of items that converge into the Time Expansion index: both groups were relatively neutral when presented with statements relating to a perception of a dilated and abundant time.

### **Caregivers vs younger**

The analysis of the STQ-present, STQ-lockdown, STQ-past indices and their related items shows how the groups of caregivers and younger students have a similar subjective experience of present time, recent past and remote past time during the lockdown.

However, the younger group reported a notably higher perception of the pressure of time (Time Pressure index; *Mdn* caregivers = 3.40; *Mdn* younger = 3.80;  $U = 313$ ;  $p = 0.021$ ).

### **Younger vs younger-pre**

Compared with a sample of younger people interviewed in a pre-lockdown period and extracted from an already acquired dataset, the group of students under lockdown shows a very slight tendency towards a slower perception of recent past time, although not significant (STQ-lockdown;  $U = 907$ ;  $p = 0.23$ ). The distinction between the two groups becomes clearer in the STQ-past index scores (*Mdn* younger = 1.00; *Mdn* younger-pre = 0.50;  $U = 1350.5$ ;  $p = 0.02$ ): a faster perception of the passage of remote past time (especially last 10 years) emerges in the group of younger people in lockdown.

### **Caregivers vs older-pre**

The group of caregivers under lockdown showed, compared with the elderly interviewed before the COVID-19 pandemic, a slightly slower perception of present (STQ-present;  $U = 171$ ;  $p = 0.29$ ) and recent past time (STQ-lockdown;  $U = 146$ ;  $p = 0.087$ ), although the scores do not differ in a statistically significant way. No differences were found in the STQ-past index scores, though the caregivers reported a notably faster perception of the passage of last 10 years (*i6*; *Mdn* caregivers = 1.00; *Mdn* older-pre = 1.00;  $U = 291$ ;  $p = 0.019$ ).

Ultimately, no statistically significant differences emerged from the comparison between the two groups on the Time Pressure and Time Expansion indices.

## DLB vs DLB-post

No statistically significant differences emerged from the comparison between the DLB group under lockdown and part of the same group examined in a post-lockdown period. Therefore, it seems that people with this type of dementia show a similarly impaired subjective perception of time passage regardless of whether they are under lockdown restrictions or not.

## Cognitive impairment

Pearson's correlation coefficient did not show any significant (all  $p > .307$ ) relationship between the *Mini Mental State Examination* (MMSE) score and the value of the STQ indices obtained by the group of DLB patients. Therefore, there seems to be no relationship between the severity of cognitive impairment and the subjective perception of time in this sample.

## Discussion

This study shows that patients with DLB are characterized, during the period of lockdown from COVID-19, by a subjective perception of time that is significantly slower compared to that of their caregivers and to a group of young students. More in detail, this slowing is mainly observed in the case of subjective judgements on the passage of present and recent past time, while it progressively declines as the length of the addressed time span increases, until disappearing for evaluations of the last 10 years. In general, these effects are not explained by age (i.e., the groups of younger and healthy older individuals obtained statistically comparable scores on these items), but they may rather reflect the impact of the disease on the investigated construct (i.e., the subjective perception of the passage of time), the extent of which grows for the time periods lived under lockdown restrictions. The exposure to stressful events such as lockdown or quarantine may indeed act as an amplifier of neuropsychiatric symptoms in people with dementia and, in the specific case of DLB patients, may further worsen their sleep pattern, their attention and reality monitoring checking, with subsequent increase of hallucinations (Cagnin et al., 2020). In this context, since the subjective experience of time is the result of the combined effect of cognitive processes and emotional states (Wittman, 2009), it is plausible that the experience of lockdown compromises the already disabling cognitive and behavioral profile of DLB patients in a way that affects their subjective perception of time as well. This hypothesis is consistent with studies (Wearden, 2015) that demonstrate how POTJs are influenced by hedonic variables, so that we expect negative psychological states that are typically associated with lockdown to induce a slowing down of the subjective experience of time, and that this effect would be particularly marked in the case of patients with DLB. In particular, time does not seem to pass either quickly or slowly for them, but nonetheless it passes significantly slower when compared with the subjective experience of time spent in lockdown by the groups of similar age caregivers and younger students.

We did not observe a similarly slowed perception in the case of distant past periods (STQ-past): this might be due to the fact that the disease had a greater impact on the subjective perception of recent time spans in the DLB patients. This hypothesis is especially valid in the case of item *i6* (How fast did the previous 10 years pass for you?"; see Supplementary Material), considering that the average time since disease onset corresponds to 2 years and 8 months for the patients recruited in this study. However, since these items (*i5*; *i6*) require retrospective evaluations, it is also likely that these assessments are affected by the current state of the disease to the same extent judgments on present or recent past time are. Therefore, it might be that the patients, given their condition, lost the ability to form metacognitive representations of long and distant time spans. With these assumptions, it is difficult to disentangle whether the current stage of the disease or the time period addressed by the question is more relevant in determining the patient's judgment.

Although not significantly as in the case of the DLB group, caregivers and younger students show numerically lower median values on the STQ-present and STQ-lockdown indices compared with their paired pre-lockdown groups (Older-pre and Younger-pre): a slowdown, albeit very slight when compared to that observed in the DLB group, of the subjective perception of time that is expected and coherent with the psychological experiences (stress, apprehension, boredom) that are typically associated with lockdown. Therefore, it would seem that in healthy individuals lockdown does not have an impact on subjective time as significant as on patients with DLB. Nonetheless, caregivers and younger individuals report a faster perception of the passage of non-recent past time frames (especially last 10 years) compared to younger and older adults interviewed before lockdown. This apparently paradoxical phenomenon could be explained by a comparative effect for which past time, compared to time lived under lockdown restrictions, seems to have flown by much more quickly.

DLB patients also show median Time Pressure scores that are lower than those of their caregivers, who in turn obtained lower scores than the group of younger people. These data suggest not only that age is an influencing variable on the perception of time pressure and the feeling of having little time available, but also that DLB leads to a further reduction of this sensation. Therefore, in this case as well DLB patients provide answers that are consistent with a detached experience towards time. On the other hand, we observed no difference between any of the studied groups in the perceived abundance of time at disposal or in the feeling of a dilated time flow (Time Expansion index).

The fact that the responses to the STQ provided by the DLB patients have not undergone significant changes following the end of the lockdown may suggest that such experience does not affect, at least in people with this diagnosis, the subjective perception of time, but also that the found alterations exclusively depend on the disease. On the other hand, the post-lockdown period during which patients were retested cannot be considered a normal living condition, considering that the pandemic was still ongoing (with elderly persons adopting measures of self-lockdown) and that the adverse psychological effects of the lockdown could still persist. Hence, from the results of this study there is no way of knowing with certainty the distinct contribution of lockdown and of the disease on determining the subjective perception of time in the examined group. In order to find out, we should have collected the

STQs in a pre-lockdown period. Since this was not done, a valid alternative option might be to wait for the complete resolution of the COVID-19 pandemic, so that typical living conditions are restored, and only then administer the questionnaire to the same group of patients. By then, however, it is likely that the patients' clinical state will have worsened, leading to a further impairment of their subjective perception of time. The only left solution is to administer the STQ to a different sample of individuals with a DLB diagnosis who have similar socio-demographic features and same disease stage in a post-COVID period.

Ultimately, the absence of significant correlations between the MMSE scores and the STQ indices suggests that the peculiar subjective experience of time of the DLB patients does not depend on the severity of their general cognitive impairment, but rather on the distinctive features of the disease (likely apathy, confusion, impaired attention and fluctuating cognition).

## Limitations

The limitations of this research are mainly identifiable in the composition of the samples. Among these, the most evident is the low number of participants, although this is reasonable considering the circumstances of implementation of this study and the specificity of the selected diagnosis. A small sample limits the generalizability of the obtained data and may hide some effects and relationships, like in the case of the MMSE scores which do not correlate with the STQ indices in the DLB group. Secondly, there is a scarce comparability in terms of age between the DLB group and the caregivers (who are approximately younger by a decade), albeit both belonging to an age range considered as old age. However, the influence of age on the subjective perception of time passage is controversial: Wittman & Lehnhoff (2005), in their work, conclude that "time speeds up subjectively as people get older", though subsequent studies (Friedman & Janssen, 2010; Janssen et al., 2013) found that age correlates only with the question about the last 10 years, showing small and non-significant correlations for the rest of the STQ items. Gender distribution is also not equally balanced between the DLB group, where male sex prevails, and their caregivers, who are mainly represented by females. Friedman & Janssen (2010) found that women tend to report higher speed-of-time scores than men (except on the 10 year item), and a similar small effect of gender on speed of time ratings was described by Janssen et al. (2013) as well. Therefore, it is possible that the results obtained from the comparison between the DLB group and the group of caregivers and the relative interpretations are influenced by such effects. Moreover, younger adults have a much higher educational level than older groups. This cohort effect is difficult to control, as younger adults with an education lower than that required by law are indeed very rare to find. Additionally, given the low number of DLB patients that can be recruited in a single center, it is not feasible to select only those with a high education. This difference in education prevents to discern with certainty whether the differences found between the two groups depend on the disease or on the fact that they belong to cohorts with different socio-cultural and educational experiences.

Ultimately, caregivers do not have a MMSE that certifies their cognitive integrity, so we can only assume that these individuals are cognitively healthy. However, the fact that many of their responses to the STQ

are statistically comparable to those of younger students and seniors of the same age suggests, albeit very indirectly, that the group has normal perception of subjective time. In light of the above limitations, it is clear that this work would benefit from a greater number of participants, as well as more evenly distributed samples in terms of age, gender, and education, in order to allow more reliable comparisons. However, the COVID-19 lockdown period represents a special but fleeting observation window.

## Conclusion

In the present research, we studied the subjective experience of time during COVID-19 lockdown in a group of people with DLB, using a shortened version of the *Subjective Time Questionnaire* developed by Wittman and Lehnhoff (2005), and compared it with the perception of a group of similar age caregivers and a group of younger students. Patients with a DLB diagnosis tend to report that time does not pass either slowly or quickly for them, and this perception of time passage is slower than the one reported by younger adults and caregivers in their responses to the questionnaire. Therefore, it seems that patients with DLB, compared with healthy controls, perceive time as passing relatively slower during the lockdown due to COVID-19 pandemic. We argue that this subjective experience may be the consequence of a cognitive-emotional slowdown resulting from the joint effect of the clinical features of the disease and the adverse influence of the experience of lockdown on the cognitive and behavioral profile of the patients. Indeed, the literature (Brooks, 2020) reports how social isolation from quarantine or lockdown is frequently associated with negative psychological outcomes including stress, fear, anxiety, mood disorders, apathy and insomnia which, in fragile people such as patients with dementia, can easily lead to an exacerbation of the symptomatology (Cagnin et al., 2020; Simonetti et al., 2020), likely affecting their cognition of time as well. In the specific case of the patients recruited in this study, it would seem that they tend to live the passage of time during the lockdown with detachment, finding refuge in a personal temporal dimension. Consistently with these findings and interpretations, the DLB patients do not report feelings of time pressure or time dilation, while healthy older and younger adults often report feeling the pressure of time, even during lockdown. Furthermore, unlike patients, caregivers and students only show a slightly slowed perception of the time lived in lockdown compared with the younger and older people who were interviewed in a previous timeframe with normal living conditions, suggesting that the imposed restrictions have a greater impact on the subjective experience of time in DLB patients than in healthy people, regardless of age differences.

Though we are aware of the limitations of this research, we provide a photograph, albeit incomplete and imperfect, of how DLB and the caregiver status of patients with DLB can interact with the isolation imposed by the lockdown restrictions on the subjective perception of time. To our best knowledge, it is the first time this construct has been studied in this type of patients. The obtained results represent an initial step in the identification of the factors that contribute to the individual experience of time in DLB.

## Declarations

### Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

### **Ethical and consent form statement**

The study was approved by the Ethics Committee of Padua's Hospital. All participants gave their informed consent to take part in this study.

### **Data availability statement**

The anonymized datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

## **References**

Allman, M., & Meck, W. (2011). Pathophysiological distortions in time perception and timed performance. *Brain*, 135(3), 656-677. doi: 10.1093/brain/awr210

Bostrom F, Jonsson L, Minthon L, Londos E. (2007) Patients with dementia with lewy bodies have more impaired quality of life than patients with Alzheimer disease. *Alzheimer Dis Assoc Disord*; 21: 150–54.

Brooks, S., Webster, R., Smith, L., Woodland, L., Wessely, S., Greenberg, N., & Rubin, G. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *The Lancet*, 395(10227), 912-920. doi: 10.1016/s0140-6736(20)30460-8

Cagnin, A., Di Lorenzo, R., Marra, C., Bonanni, L., Cupidi, C., Laganà, V., ... & Vanacore, N. and SINdem COVID-19 Study Group\* (\*Bussè C.). (2020). Behavioral and psychological effects of coronavirus disease-19 quarantine in patients with dementia. *Frontiers in Psychiatry*, 11:578015.

doi: 10.3389/fpsy.2020.578015

Droit-Volet, S. (2013). Time perception, emotions and mood disorders. *J. Physiol. Paris*, 107, 255–264. doi: 10.1016/j.jphysparis.2013.03.005.

Droit-Volet, S., Gil, S. (2009). The time-emotion paradox. *Philos Trans R Soc Lond B Biol Sci*, 364(1525), 1943-53. doi: 10.1098/rstb.2009.0013.

Droit-Volet, S., & Meck, W. H. (2007). How emotions colour our perception of time. *Trends Cogn. Sci.*, 11, 504–513.

- Finnerty, G. T., Shadlen, M. N., Jazayeri, M., Nobre, A. C., & Buonomano, D. V. (2015). Time in cortical circuits. *Journal of Neuroscience*, 35(41), 13912–13916. doi.org/10.1523/JNEUROSCI.2654-15.2015
- Friedman, W., & Janssen, S. (2010). Aging and the speed of time. *Acta Psychologica*, 134(2), 130-141. doi: 10.1016/j.actpsy.2010.01.004
- Gabrian, M., Dutt, A., & Wahl, H. (2017). Subjective Time Perceptions and Aging Well: A Review of Concepts and Empirical Research - A Mini-Review. *Gerontology*, 63(4), 350-358. doi: 10.1159/000470906
- Janssen, S., Naka, M., & Friedman, W. (2013). Why does life appear to speed up as people get older?. *Time & Society*, 22(2), 274-290. doi: 10.1177/0961463x13478052
- Jokic, T., Zakay, D., & Wittmann, M. (2018). Individual differences in self-rated impulsivity modulate the estimation of time in a real waiting situation. *Timing Time Percept.*, 6, 71–89.
- Kramberger, M., Auestad, B., Garcia-Ptacek, S., Abdelnour, C., Olmo, J., & Walker, Z. et al. (2017). Long-Term Cognitive Decline in Dementia with Lewy Bodies in a Large Multicenter, International Cohort. *Journal Of Alzheimer's Disease*, 57(3), 787-795. doi: 10.3233/jad-161109
- Lesimple, B., Dieudonné, B., Campillo-Gimenez, B., Verny, M., & Giannopulu, I. (2016). Étude préliminaire de la perception du temps chez les patients présentant une démence à corps de Lewy. *Geriatric et Psychologie Neuropsychiatrie Du Vieillessement*, 14(2), 213–220. doi.org/10.1684/pnv.2016.0604
- Marinho, V., Oliveira, T., Rocha, K., Ribeiro, J., Magalhães, F., & Bento, T. et al. (2017). The dopaminergic system dynamic in the time perception: a review of the evidence. *International Journal of Neuroscience*, 128(3), 262-282. doi: 10.1080/00207454.2017.1385614
- Matar, E., Martens, K., Phillips, J., Halliday, G., & Lewis, S. (2019). Altered interval timing as a novel marker of cognitive fluctuations in lewy body dementia. *Journal of Neurology, Neurosurgery & Psychiatry*, 90(e7), A1.1-A1. doi: 10.1136/jnnp-2019-anzan.1
- McKeith, I., Boeve, B., Dickson, D., Halliday, G., Taylor, J., & Weintraub, D. et al. (2017). Diagnosis and management of dementia with Lewy bodies. *Neurology*, 89(1), 88-100. doi: 10.1212/wnl.0000000000004058
- Merchant, H., Harrington, D. L., & Meck, W. H. (2013). Neural Basis of the Perception and Estimation of Time. *Annual Review of Neuroscience*, 36(1), 313–336. doi.org/10.1146/annurev-neuro-062012-170349
- Migliaccio, R., & Bouzigues, A. (2020). Dementia and COVID-19 Lockdown: More Than a Double Blow for Patients and Caregivers. *Journal of Alzheimer's disease reports*, 4(1), 231–235. doi.org/10.3233/ADR-200193
- Mioni, G., Wittmann, M., Prunetti, E., & Stablum, F. (2020). Time Perspective and the Subjective Passage of Time in Patients with Borderline Personality Disorders. *Timing & Time Perception*, 8(1), 86-101. doi:

10.1163/22134468-20191165

Mueller, C., Ballard, C., Corbett, A., & Aarsland, D. (2017). The prognosis of dementia with Lewy bodies. *The Lancet Neurology*, 16(5), 390–398. doi.org/10.1016/S1474-4422(17)30074-1

Paton, J. J., & Buonomano, D. V. (2018). The Neural Basis of Timing: Distributed Mechanisms for Diverse Functions. *Neuron*, 98(4), 687–705. doi.org/10.1016/j.neuron.2018.03.045

Price, A., Farooq, R., Yuan, J., Menon, V., Cardinal, R., & O'Brien, J. (2017). Mortality in dementia with Lewy bodies compared with Alzheimer's dementia: a retrospective naturalistic cohort study. *BMJ Open*, 7(11), e017504. doi: 10.1136/bmjopen-2017-017504

Rongve, A., Vossius, C., Nore, S., Testad, I., & Aarsland, D. (2013). Time until nursing home admission in people with mild dementia: comparison of dementia with Lewy bodies and Alzheimer's dementia. *International Journal Of Geriatric Psychiatry*, 29(4), 392-398. doi: 10.1002/gps.4015

Rubin GJ, & Wessely S. (2020) The psychological effects of quarantining a city. *BMJ*, 368: m313. doi: 10.1136/bmj.m313.

Simonetti, A., Pais, C., Jones, M., Cipriani, M. C., Janiri, D., Monti, L., Landi, F., Bernabei, R., Liperoti, R., & Sani, G. (2020). Neuropsychiatric Symptoms in Elderly With Dementia During COVID-19 Pandemic: Definition, Treatment, and Future Directions. *Frontiers in Psychiatry*, 11, 579842. <https://doi.org/10.3389/fpsy.2020.579842>

Svendsboe, E., Terum, T., Testad, I., Aarsland, D., Ulstein, I., Corbett, A., & Rongve, A. (2016). Caregiver burden in family carers of people with dementia with Lewy bodies and Alzheimer's disease. *International Journal Of Geriatric Psychiatry*, 31(9), 1075-1083. doi: 10.1002/gps.4433

Teixeira, S., Machado, S., Paes, F., Velasques, B., Guilherme Silva, J., L Sanfim, A., ... Arias-Carrion, O. (2013). Time perception distortion in neuropsychiatric and neurological disorders. *CNS Neurol. Disord. Drug Targets*, 12, 567–582.

Wearden, J. H., O'Donoghue, A., Ogden, R., & Montgomery, C. (2014). Subjective duration in the laboratory and the world outside. In V. Arstila & D. Lloyd (Eds.), *Subjective time: The philosophy, psychology, and neuroscience of temporality* (pp. 287–306). Cambridge, MA: MIT Press.

Wearden, J. (2015). Passage of time judgements. *Consciousness and cognition*. doi.org/10.1016/j.concog.2015.06.005

Williams, M. M., Xiong, C., Morris, J. C., & Galvin, J. E. (2006). Survival and mortality differences between dementia with Lewy bodies vs Alzheimer disease. *Neurology*, 67(11), 1935–1941. doi:10.1212/01.wnl.0000247041.63081.98

Wittmann, M. (2009). The inner experience of time. *Philosophical Transactions Of The Royal Society B: Biological Sciences*, 364(1525), 1955-1967. doi: 10.1098/rstb.2009.0003

Wittman, M., & Lehnhoff, S. (2005). Age Effects In Perception Of Time. *Psychological Reports*, 97(7), 921. doi: 10.2466/pr0.97.7.921-935

Yao, H., Chen, J.H., Xu, Y.F. (2020). Patients with mental health disorders in the COVID-19 epidemic. *Lancet Psychiatry*, 7(4). doi: 10.1016/S2215-0366(20)30090-0.

Zakay, D., & Block, R. A. (1997). Temporal cognition. *Curr. Dir. Psychol. Sci.*, 6, 12–16.

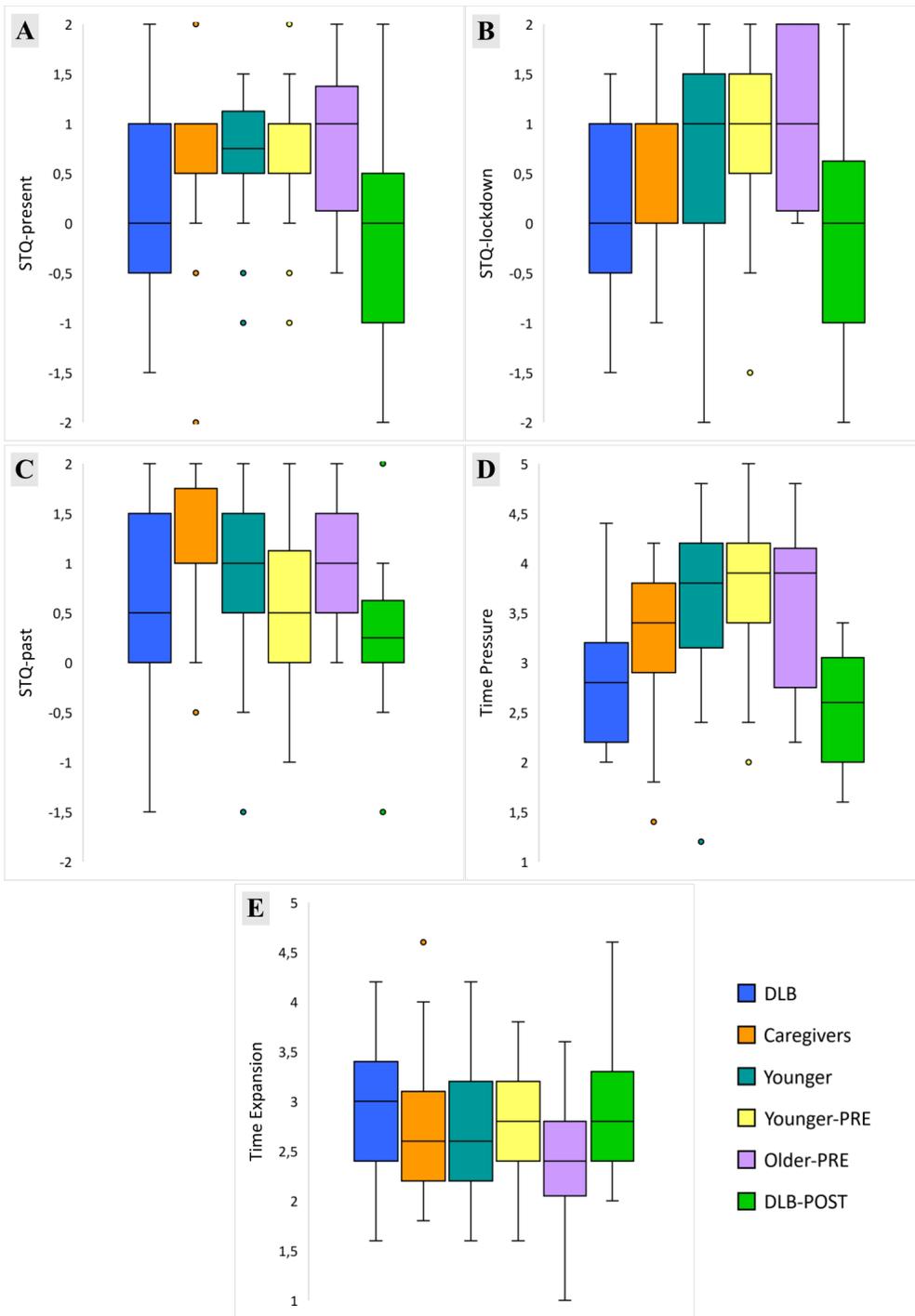
## **Appendix**

### **SUBJECTIVE TIME QUESTIONNAIRE items and scoring (Wittman & Lehnhoff, 2005)**

<b>English version</b>					
<b>SUBJECTIVE TIME QUESTIONNAIRE (Wittman &amp; Lehnhoff, 2005)</b>					
<b><i>Personal time experience of present and past</i></b>					
<i>(-2 = very slowly, -1 = slowly, 0 = neither fast nor slow, 1 = slowly, 2 = very slowly)</i>					
		-2	-1	0	1 2
<b><i>i1)</i></b> How fast does time usually pass for you?					
<b><i>i2)</i></b> How fast do you expect the next hour to pass?					
<b><i>i3)</i></b> How fast did the previous week pass for you?					
<b><i>i4)</i></b> How fast did the previous month pass for you?					
<b><i>i5)</i></b> How fast did the previous year pass for you?					
<b><i>i6)</i></b> How fast did the previous 10 years pass for you?					
<b><i>Statements on subjective time experience</i></b>					
<i>(1 = strong rejection, 2 = rejection, 3 = neutral, 4 = approval, 5 = strong approval)</i>					
<b><i>ii1)</i></b> I haven't enough time to complete my tasks		1	2	3	4 5
<b><i>ii2)</i></b> My time seems empty					
<b><i>ii3)</i></b> I often think that time just does not want to pass					
<b><i>ii4)</i></b> I often feel time pressure					
<b><i>ii5)</i></b> I often haven't enough time to devote myself to important things					
<b><i>ii6)</i></b> I often feel bored					
<b><i>ii7)</i></b> I often think time is running out					
<b><i>ii8)</i></b> I have a lot of time					
<b><i>ii9)</i></b> I often have spent my time without doing anything					
<b><i>ii10)</i></b> I have to establish my priorities, because I cannot do all the things I would like to do					

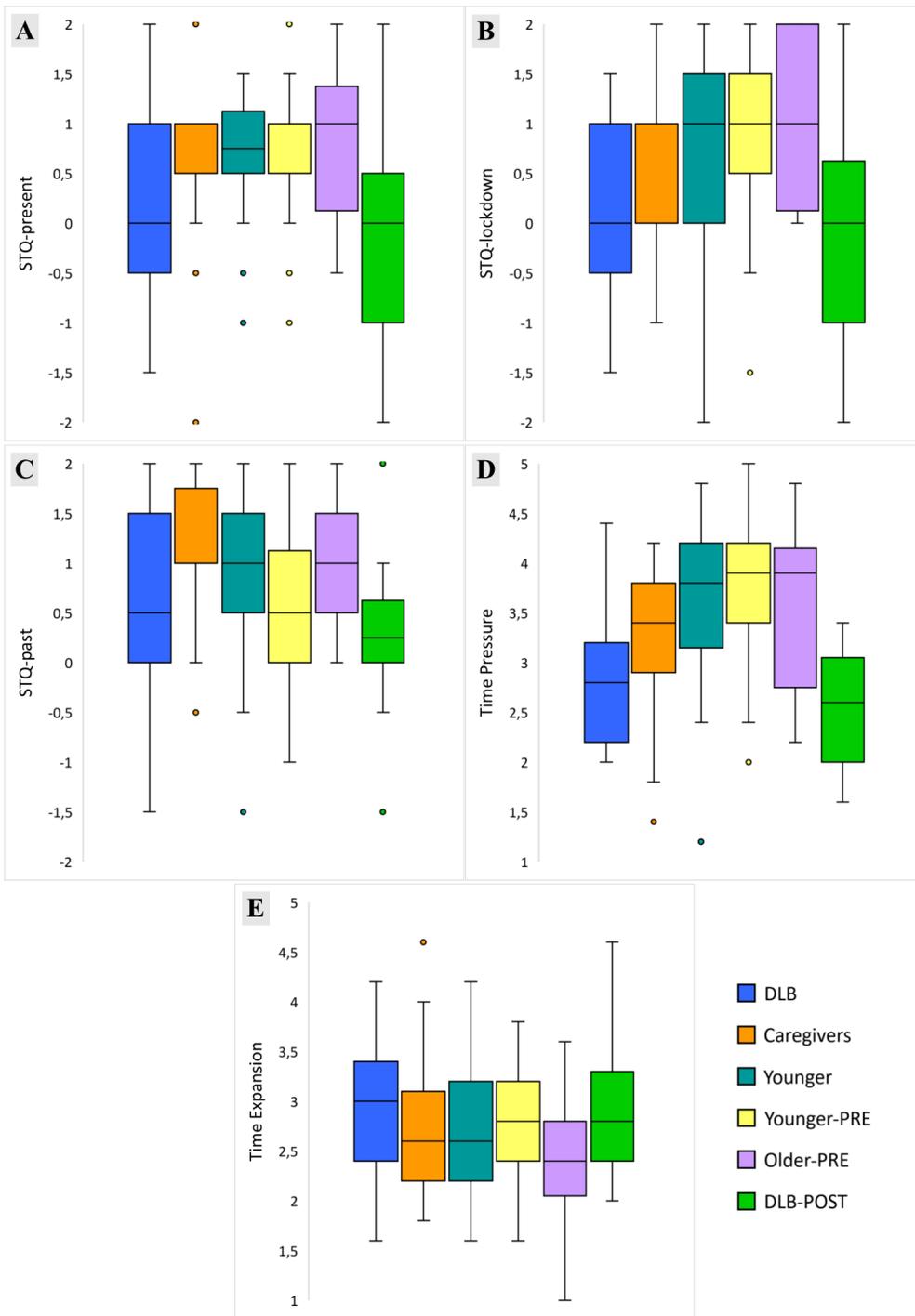
Italian Version					
QUESTIONARIO DELLA PERCEZIONE SOGGETTIVA DEL TEMPO (Mioni et al., 2020)					
<b>Esperienza temporale personale del presente e del passato</b>					
<i>(-2 = molto lentamente, -1 = lentamente, 0 = né veloce né lento, 1 = velocemente, 2 = molto velocemente)</i>					
	-2	-1	0	1	2
<b>i1)</b> Solitamente quanto veloce passa il tempo per te?					
<b>i2)</b> Quanto velocemente ti aspetti che passerà la prossima ora?					
<b>i3)</b> Quanto velocemente è trascorsa la precedente settimana per te?					
<b>i4)</b> Quanto velocemente è trascorso lo scorso mese per te?					
<b>i5)</b> Quanto velocemente è passato lo scorso anno per te?					
<b>i6)</b> Quanto velocemente sono trascorsi per te gli ultimi 10 anni?					
<b>Enunciati sull'esperienza soggettiva del tempo</b>					
<i>(1 = fortemente in disaccordo, 2 = in disaccordo, 3 = neutrale, 4 = d' accordo, 5 = fortemente d'accordo)</i>					
<b>ii1)</b> Non ho abbastanza tempo per completare ciò che ho da fare	1	2	3	4	5
<b>ii2)</b> Il mio tempo non è completamente pieno di cose da fare					
<b>ii3)</b> Spesso penso che il tempo non voglia passare					
<b>ii4)</b> Sento spesso la pressione del tempo					
<b>ii5)</b> Spesso non ho abbastanza tempo per dedicarmi alle cose che giudico importanti					
<b>ii6)</b> Spesso mi sento annoiato					
<b>ii7)</b> Spesso penso che il tempo stia "correndo via"					
<b>ii8)</b> Ho un sacco di tempo a disposizione					
<b>ii9)</b> Spesso devo usare il mio tempo facendo qualcosa					
<b>ii10)</b> Devo stabilire delle priorità, poiché non posso fare tutte le cose che mi piacerebbe fare					

## Figures



**Figure 1**

A) Distribution of the samples on STQ-present index. B) Distribution of the samples on STQ-lockdown index. C) Distribution of the samples on STQ-past index. D) Distribution of the samples on Time Pressure index. E) Distribution of the samples on Time Expansion index. DLB = dementia with Lewy bodies.



**Figure 1**

A) Distribution of the samples on STQ-present index. B) Distribution of the samples on STQ-lockdown index. C) Distribution of the samples on STQ-past index. D) Distribution of the samples on Time Pressure index. E) Distribution of the samples on Time Expansion index. DLB = dementia with Lewy bodies.

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