The Blursday database as a resource to study subjective temporalities during COVID-19

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The COVID-19 pandemic and associated lockdowns triggered worldwide changes in the daily routines of human experience. The Blursday database provides repeated measures of subjective time and related processes from participants in nine countries tested on 14 questionnaires and 15 behavioural tasks during the COVID-19 pandemic. A total of 2,840 participants completed at least one task, and 439 participants completed all tasks in the first session. The database and all data collection tools are accessible to researchers for studying the effects of social isolation on temporal information processing, time perspective, decision-making, sleep, metacognition, attention, memory, self-perception and mindfulness. Blursday includes quantitative statistics such as sleep patterns, personality traits, psychological well-being and lockdown indices. The database provides quantitative insights on the effects of lockdown (stringency and mobility) and subjective confinement on time perception (duration, passage of time and temporal distances). Perceived isolation affects time perception, and we report an inter-individual central tendency effect in retrospective duration estimation.

Subjective time is one of the most malleable aspects of personal experience and can be altered by many exogenous factors (for example, physical features of the environment and social interactions) as well as endogenous psychological and physiological states (for example, arousal, attention, valence, febricity and circadian rhythms)[1]. An altered sense of time can be indicative of individuals' well-being[2] and misguide individuals' decisions and judgements[3]. At a historically global scale, the COVID-19 pandemic and associated lockdowns and state-of-emergency measures deeply altered the living conditions, social interactions and psychological, physiological and economic well-being of the entire human population[4]. Psychological research has mostly focused on the effects of the pandemic and of the confinement on mental health (for example, WHO; https://www.covidminds.org; ref. [5]), but how the pandemic affected our sense of time, although a prominent topic of pandemic-related anecdotal reports, has not been examined in a systematic manner.

The Blursday project tackles this challenge and provides a dataset for characterizing the temporalities of hundreds of participants (Supplementary Table 1) collected in nine countries (on four continents) during the peak of the lockdown periods. The Blursday database contains various widely utilized behavioural tasks (performance measures) combined with questionnaires (self-reports), demographics and subjective confinement trackers (state measures). The database includes participants tracked longitudinally in and out of lockdown (from 2020 on) together with control groups of participants tested for the first time outside of COVID-19 lockdowns (from 2021 on). The study has thus been designed to investigate how temporalities and related processes changed during the historical episode of the COVID-19 pandemic.

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There are several reasons why time perception is central, beyond the observation that disorientations in time were a phenomenologically vivid and widely shared experience during lockdowns. First, all animals keep track of time at multiple timescales regulated by physiological clocks—for example, circadian rhythms, interval timing and motor timing[6,7]. Second, interval timing in the seconds-to-minutes range is the most malleable because it holds strong ties with domain-general cognition including attention, memory and decision-making[8]. Timekeeping systems also interact with each other: interval and motor timing fluctuate with circadian rhythms, which is essential for the adaptiveness of other cognitive functions and related behaviours[9]. In turn, the accuracy and precision of temporal representations and behaviours influence decision-making[10]. Temporal phenomenologies are thus crucial for our understanding of how cognition generally and timekeeping specifically have been affected by the altered lifestyles and profound routine changes during the lockdown periods.

Recent studies have started showing changes in sleep patterns[11–13], changes in levels of physical activity[14] and increases in depression, anxiety and fear across countries[515–17]. COVID-19 lockdowns have been suggested to negatively affect executive functions, attention and anecdotally temporal orientation through the self-reporting of forgotten dates during that period[18]. On the basis of the established relations between these cognitive and affective factors and interval timing, one would expect our timekeeping ability to be dramatically affected by lockdowns.

Self-reports on the passage of time during lockdown have been promptly published. In an Italian study[12], surveyed participants reported experiencing problems with keeping track of the hours and days, and they also reported an expansion of subjective duration, which was associated with a sense of boredom. In French surveys, participants answered the question: "What are your feelings about the speed of passage of time?"[19–21]. The question was asked in reference to the individuals' autobiographical recall of their experienced passage of time before the lockdown and was then asked three times during lockdown in reference to "now", to "yesterday" and to "one week ago". A trend towards the passage of time feeling slower during than before the lockdown was reported for all temporal scales. The best predictors of the experience of the passage of time were boredom and sadness, which contributed the most to the well-being of French participants during and after lockdown. In the UK surveys[22,23], participants reported a significant distortion of the passage of time in both directions, attributable to stress but also to age, task load and one's satisfaction with the experienced social interactions. Comparable numbers of participants felt that the past day and the past week had passed either more quickly or more slowly than usual; additionally, the older and less socially satisfied British individuals were, the slower time seemed to pass during both UK lockdowns. In a Uruguayan study[24], which assessed the experience of university students, the authors reported an association between psychological distress due to the COVID-19 restrictions and the feeling of a slower passage of time, a blurred sense of time (not knowing what time or day it is) and more boredom. In a longitudinal Brazilian study[25], participants initially perceived an expansion of time, which steadily decreased over the following weeks. These surveys confirmed self-reported temporal distortions during lockdown but do not converge on their underlying explanatory causes. Several experimental limitations include the absence of controls, which prevents assigning a causal role of lockdown to temporal distortions, and the possibility that cross-cultural factors and differences in the stringency of the lockdown measures played crucial roles in the different trends observed across countries. All studies used questionnaires and ratings, and none included psychometric tasks. The Blursday database includes a battery of questionnaires, tasks and tests (Table 1) across cultures, a longitudinal assessment of these factors within individuals and, importantly, control participants who are naive to

all tasks, who are tested outside of lockdowns and whose number can be incremented over time.

We provide a dataset that captures subjective time and timing behaviours of participants on nearly all aspects of temporal information processing (interval perception and production, spontaneous tapping, synchronization and implicit timing) together with measures of working memory, decision-making, self-perception, metacognition, sleep patterns, personality traits and well-being. The Blursday database can incorporate new control data, although the current database already contains some control data (Methods and Supplementary Fig. 1). We make all tools available online for researchers wishing to test participants post-lockdown using the same approach or parts of it. We fully describe the database and, importantly, provide examples illustrating its potential use based on a few fundamental analyses providing quantitative insights on time perception during this historical period.

Results

We report quantitative observations regarding the effect of lockdowns on psychophysical measures of subjective temporality, including retrospective duration estimation and ratings of the felt passage of time and subjective temporal distances.

Retrospective duration on the scale of minutes to hours. In the retrospective duration task ('Tasks' in the Methods and Supplementary Figs. 2 and 3), we asked the participants to provide an estimate (in minutes and seconds) of how much time had elapsed since the last time they had logged on to the study website, which was time-stamped in the collected data.

Retrospective duration estimates scale with clock duration. We initially predicted that the retrospective duration estimates would be closely associated with the actual clock duration. To test this, we used a linear regression of the logarithm of retrospective duration estimates as a function of the logarithm of clock duration, separately for the data collected during the first lockdown (Session 1 (S1)) and those collected outside of lockdown (Control Session (SC)). With this approach, we could show that the participants performed the task as expected in both sessions and thus that the data passed our soundness check: retrospective duration estimates increased with increasing clock duration (Fig. 1a). The participants' retrospective responses accounted for 59% (η^2) of the actual variability.

Interestingly, these relationships also abided by Vierordt's law and the central tendency effect typically reported in magnitude estimations[26–28], despite the between-participants design. The deviations of retrospective duration estimates from clock durations were scale-dependent such that all participants tended to overestimate the short durations and underestimate the long durations, as shown by the regression coefficients of clock duration against retrospective duration being below one for both the lockdown sessions and the SC (S1: 0.89 ± 0.019 s.e.m., two-tailed t-test against 1, $t(1,739) = -5.4$, $P < 0.0001$; SC: 0.77 ± 0.042 s.e.m., $t(1,739) = -5.6$, $P < 0.0001$). In terms of Stevens's psychophysical law mapping a sensory continuum to a psychological representation[29,30], a coefficient of regression below one can be understood as a power exponent being lower than one. In duration estimation, a value below one is consistent with an overestimation of shorter durations and an underestimation of longer durations. In a Bayesian framework, this value can also be interpreted as specifying the weight of uncertainty relative to prior knowledge[28].

We then hypothesized that the parameters of the linear function mapping subjective time and objective time would differ during and after lockdown (S1 and SC, respectively). To test this working hypothesis, we used a linear regression with session (two levels: S1 and SC) and the logarithm of clock duration (in minutes) as regressors. An analysis of variance on the outcomes of the fitted model

Table 1 | Overview of tasks and questionnaires

	S1: lockdown	S2: two weeks after lockdown	S3: three months after lockdown	S4: confinement 2 (France and Italy)	Control
Questionnaires	Confinement status Demographics Environment and social connectivity (UCLA) Isolation questionnaire Morningness–Eveningness Questionnaire (rMEQ) µMCTQ Daily sleep quality Zimbardo Time Perspective Inventory (ZTPI) Hospital Anxiety and Depression Scale (HADS) Pittsburgh Sleep Quality Index (PSQI) Big Five Inventory (BFI-10) Attentional Style Questionnaire (ASQ) Self-Perception (PQ16) FFA	Confinement status UCLA Isolation questionnaire HADS PSQI µMCTQ Daily sleep quality FFA	Confinement status UCLA Isolation questionnaire HADS PSQI µMCTQ Daily sleep quality PQ16 FFA	Questionnaires Confinement status UCLA Isolation questionnaire HADS PSQI week µMCTQ week Daily sleep quality	Confinement status Demographics UCLA Isolation questionnaire rMEQ µMCTQ Daily sleep quality ZTPI HADS PSQI BFI-10 ASQ PQ16 FFA
Tasks	Retrospective duration Passage of time Subjective temporal distance Temporal landmark Fluency tasks (phonemic, semantic, time semantic, past and future) Duration production and metacognition Tapping and synchronization Delay discounting *n*-back working memory, prospective duration and passage of time Counting task and duration estimation Foreperiod Self-preference	Retrospective duration Passage of time Subjective temporal distance Temporal landmark Fluency tasks (phonemic, semantic, time semantic, past and future) Duration production and metacognition Tapping and synchronization Delay discounting *n*-back working memory, prospective duration and passage of time Counting task and duration estimation Foreperiod Self-preference	Retrospective duration Passage of time Subjective temporal distance Temporal landmark Fluency tasks (phonemic, semantic, time semantic, past and future) Duration production and metacognition Tapping and synchronization Delay discounting *n*-back working memory, prospective duration and passage of time Counting task and duration estimation Foreperiod Self-preference	Subjective temporal distance Retrospective duration	Retrospective duration Passage of time Subjective temporal distance Temporal landmark Fluency tasks (phonemic, semantic, time semantic, past and future) Duration production and metacognition Tapping and synchronization Delay discounting *n*-back working memory, prospective duration and passage of time Foreperiod Self-preference

S1 and S4 took place during the first and second lockdowns, respectively. S2 and S3 were set at least two weeks and three months after the first lockdown. Thus, S1, S2, S3 and S4 tested the same set of participants longitudinally in and out of lockdown. The SC tested a group of naive participants on the same set of questionnaires and tasks as those tested in S1 (during the first lockdown). A detailed description of S1 is provided in the Supplementary Information.

confirmed a significant main effect of the log of clock duration on subjective retrospective duration estimates ($F(1, 1{,}739) = 2{,}462.05$; $P < 2 \times 10^{-16}$; $\eta^2 = 0.59$; 95% confidence interval (CI), (0.86, 0.93)) and a significant interaction between retrospective duration and session ($F(1, 1{,}739) = 7.57$; $P = 0.006$; $\eta^2 = 4.3 \times 10^{-3}$; 95% CI, (−0.22, −0.036)). This interaction captures the observation that the regression slopes in each session differed significantly. To illustrate these effects and make this observation more tangible, the model fits show that a clock duration of ten minutes was overestimated by $30\,s \pm 15\,s$ (estimated mean ± s.e.m.) during the first lockdown (S1) but by $92\,s \pm 36\,s$ during the SC. Conversely, a clock duration of 1 h was underestimated by 7 min and $10\,s \pm 54\,s$ (thus, estimated as ~52 min) during the first lockdown (S1) but by 14 min and $20\,s \pm 108\,s$ (thus, estimated as ~46 min) outside of it (SC).

As an extension to these observations, the durations that were most accurately estimated by the participants were expected to differ during and outside of the lockdown periods. Consistent with this prediction, our analyses revealed the existence of a possible

'indifference interval' in retrospective duration estimation, which converges in both sessions at a relatively close clock duration of about a quarter of an hour.

Effect of stringency and mobility on retrospective duration. Next, as stringency and mobility indices did not strictly map with the experimental sessions (Supplementary Fig. 1), we used data from all sessions (S1, S2, S3, S4 and SC) and quantified the severity of lockdown using the stringency, mobility and subjective confinement indices described in the Methods. We also included age and time of day as possible covariates, which are known factors arguably influencing the estimation of duration[30–32]. First, we modelled the error term related to participants as a random intercept using a linear mixed model approach on the participants' relative retrospective duration estimates[33]. We quantified the relative duration estimations as retrospective duration estimation divided by clock duration to pull all temporal scales together. The standard deviation of the estimated random effects was smaller than that of the residuals, suggesting
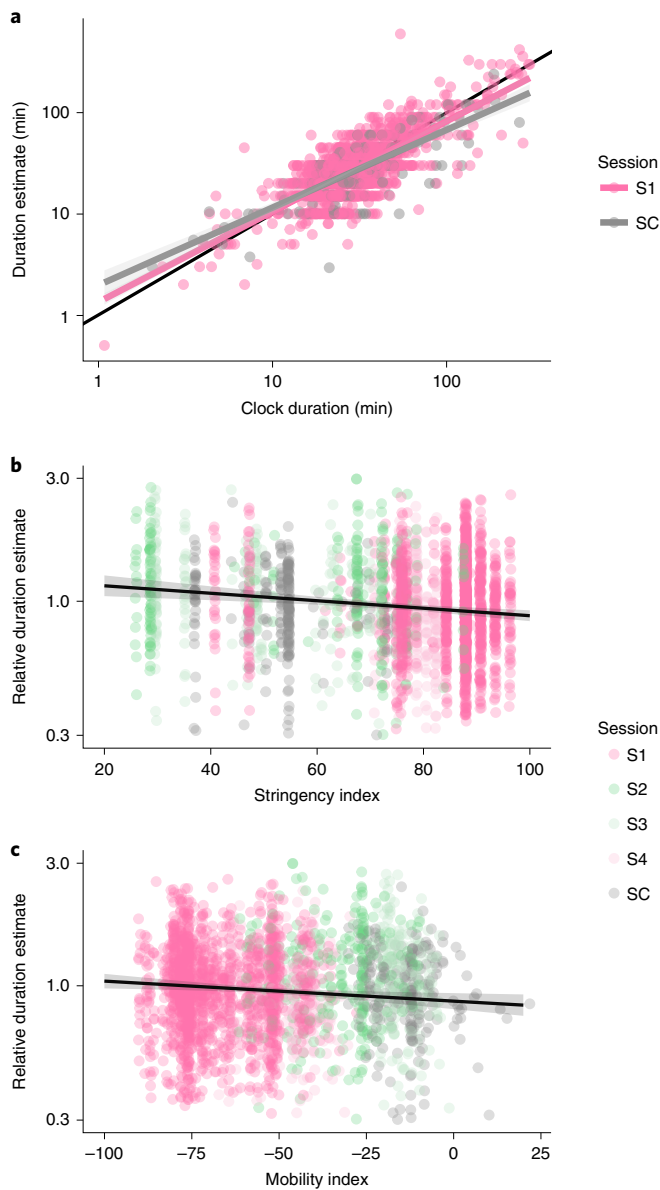
Fig. 1 | Retrospective duration estimation is affected by lockdown, lockdown stringency and mobility. a, Retrospective duration estimates (minutes) as a function of veridical clock duration (minutes) during lockdown (S1; pink) and outside of it (SC; grey). Each dot represents a single participant. The regression lines were estimated from the linear mixed effect model; their 95% CIs are shown with grey shading. **b**, Relative retrospective duration estimates (unitless) as a function of the stringency index (a.u. between 0 and 100) for all sessions (coloured). The coloured dots are individual data points per participant and per session. The regression line was estimated from the linear model; the 95% CI is shown with grey shading. The more stringent governmental rules were, the shorter retrospective durations were estimated to be. **c**, Relative retrospective duration estimates (unitless) as a function of the mobility index (percent change relative to baseline, prior to lockdown; see the main text) for all sessions (coloured). Each dot is an individual data point per participant and per session. The black line is a regression line estimated from the linear model; the 95% CI is shown with grey shading. The closer to baseline mobility, the shorter retrospective durations were estimated to be.

that random effects could be ignored and that running a linear model with the same fixed effects revealed similar outcomes. Hence, we solely report the fixed effects analysis.

Second, using an analysis of variance on the coefficient estimates of the linear mixed model revealed a significant effect of the stringency index ($F(1, 2,140) = 8.54$; $P = 0.003$; $\eta^2 = 4 \times 10^{-3}$; 95% CI, ($-2.1 \times 10^{-3}$, -0.7×10^{-3}); Fig. 1b) and of the mobility index ($F(1, 2,140) = 8.12$; $P = 0.004$; $\eta^2 = 3.8 \times 10^{-3}$; 95% CI, ($-1.3 \times 10^{-3}$, -0.2×10^{-3}); Fig. 1c) on relative retrospective duration estimates. To translate this effect into words, an increase of 80 on the stringency scale (that is, from the least to the most stringent states in the range of available data) corresponded to a decrease of 30% in estimated retrospective duration so that the more stringent the governmental measures were, the shorter the retrospective duration estimates were. Conversely, the effect of the mobility index suggests that the closer to normal mobility the participants were, the shorter the retrospective duration estimates were. Thus, stringency and mobility distinctly affect retrospective duration during the pandemic. As seen in Fig. 1c, our sessions and data collections seemed to align well with the mobility index. We observed no significant effects of the subjective confinement index, age or hour of day on retrospective duration estimates (all $F < 1.7$, $P > 0.15$).

Passage of time on the scale of a few days. Studies that have explored the effects of lockdown on time perception have converged on the notion that participants experienced temporal distortions, with a slowing down of the passage of time and an expansion of experienced time over days, both accounted for by factors such as boredom, sadness or depression during lockdowns[19,20,22,23,25]. Here we hypothesized that participants' experienced temporal distortions could be affected by how stringent the lockdowns were as well as individuals' ability to move freely (the stringency and mobility indices provided objective measures of confinement; Methods). Alternatively, it might not be the objective levels of stringency and mobility, per se, that would cause the experienced temporal distortions, but the participants' subjective feeling of being confined and their felt social isolation (subjective confinement measures; Methods). We therefore posited that these subjective measures could be better predictors of the experienced feelings of how fast time seemed to pass during lockdowns.

To test these hypotheses, we explored four subjective time measurements collected using the participants' ratings on a visual analogue scale (VAS): the passage of time (over a few days), the subjective temporal distance from the first day of lockdown (past temporal orientation) and the subjective temporal distances to one week and to one month from now (future temporal orientation). For all four, we used a linear mixed effect model with covariates identical to those used for the retrospective duration estimates: stringency index, mobility index, subjective confinement index, age and hour of day. For all measures of subjective temporal distances, a random intercept per participant was added.

To capture the temporal phenomenology of the felt passage of time, individuals can rate their feeling of how fast time is passing over a certain lapse of time using a VAS. This approach was used in previous studies[19–23,27,34]. In Blursday, we predicted that the degree of felt social isolation would affect the speed of subjective time as measured by the VAS. We asked the participants to rate their feeling of the passage of time over the past few days. With a linear regression approach, we found that the passage of time was significantly related to participant subjective confinement score ($F(1, 1,860) = 28.44$; $P = 1.087 \times 10^{-7}$; $\eta^2 = 0.02$; 95% CI, (0.58, 1.26); Fig. 2), so that the more isolated the participants felt, the slower their impressions of the passage of time were. Under the linear assumption (that is, away from the boundaries of the VAS), the most extreme differences in subjective score of confinement (from 5, feeling most confined, to 20, feeling least confined) corresponded, on average, to a difference of 13.8 on the passage of time VAS, from 53.9 ± 1.7 to 67.7 ± 1.3. No other tested factors were found to significantly affect the participants' passage of time.
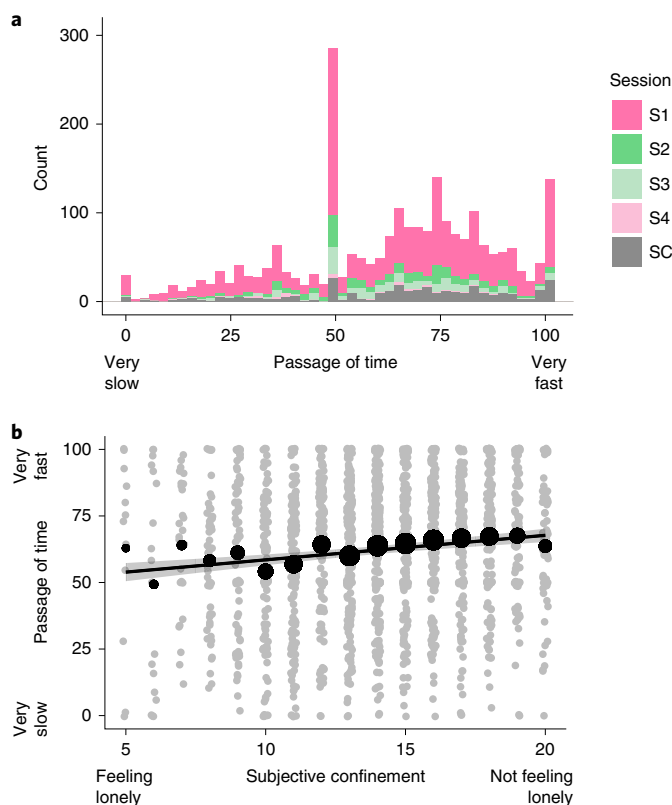
Fig. 2 | Passage of time and subjective confinement. a, Distribution of VAS rating (0 to 100) counts for passage-of-time judgements as a function of session (colour coded). **b**, Passage-of-time ratings as a function of subjective confinement (5 to 20). The grey dots are individual data points (per participant, per session, per run). The black dots are the mean passage-of-time ratings binned by subjective confinement. Their size scales with the underlying number of individual data points. The black line is a regression line estimated from the linear mixed effect model; the 95% CI is shown with grey shading. The less lonely the participants felt, the faster the passage of time felt.

Ratings of the passage of time assessed with a VAS have been argued to provide a relevant tool for the experience of time in real-life situations[35]. Our analysis suggests that the experience of the 'flow of time' is strongly affected by how isolated individuals felt over the scale of days, but not by actual stringency or mobility. Neither age nor time of day was found to significantly alter the subjective passage of time. To disentangle the contributions of objective and subjective measures of confinement on individuals' experience of time, we turned to well-known cognitive measures of temporal orientation and subjective temporal distances.

Past and future temporal orientation and distances. The dilation and slowing down of the passage of time previously reported during social isolation[25] would predict that the more isolated participants were, the longer they should estimate temporal distances. As above, we tested this working hypothesis with both objective and subjective indices using a linear mixed effect model with the stringency index, the mobility index, the subjective confinement index, age and hour of day as covariates and the participant as a random factor. In these tasks, the participants reported on a VAS ranging from 0 (very close) to 100 (very far) their subjective temporal distance from the first day of lockdown (past orientation) or to the week and month to come (future orientation).

The subjective temporal distances from the first day of lockdown (past orientation) were significantly affected by the mobility index ($F(1, 3,814) = 80.25$; $P \leq 2.2 \times 10^{-16}$; $\eta^2 = 0.02$; 95% CI, (0.20, 0.32); Fig. 3a), so that the closer to normal mobility, the further away the participants rated their first day of lockdown to feel. Under the linear assumption (that is, away from the VAS boundaries), the most extreme increase in mobility (from −90 to 0) corresponded, on average, to a difference of 23.5 points on the subjective temporal distance scale, which went from 52.9 ± 1.2 to 76.4 ± 1.8. Conversely, the participants' subjective confinement scores significantly affected their subjective temporal distances from the first day of lockdown ($F(1, 2,742) = 9.6$; $P = 0.0019$; $\eta^2 = 3.5 \times 10^{-3}$; 95% CI, (−0.79, −0.18); Fig. 3b). Under the linear assumption, the less subjectively isolated the participants felt (with the subjective confinement score going from 5 to 20), the closer in time that day felt. On average, an increase of the subjective confinement score (interpreted as feeling less isolated) of 7.3 resulted in the participants' subjective temporal distance being rated as closer (from 65.7 ± 1.6 to 58.4 ± 1.1).

We then explored the participants' future orientation with the subjective temporal distances at two timescales, 'next week' and 'next month' (Fig. 3c, light and dark green, respectively). A first effect common to both timescales was driven by the age of the participants (week: $F(1, 910) = 12.23$; $P = 0.00049$; $\eta^2 = 0.01$; 95% CI, (−0.25, −0.07); month: $F(1, 949) = 25.63$; $P = 4.97 \times 10^{-7}$; $\eta^2 = 0.03$; 95% CI, (−0.35, −0.16); Fig. 3d,e). Under the linear assumption, the most extreme differences in age (from 18 to 88 years old) corresponded to an average difference of −11.2 on the subjective temporal distance scale for 'next week' (from 36.7 ± 1.19 to 25.5 ± 2.51) and of −17.9 for 'next month' (from 60.4 ± 1.20 to 42.5 ± 2.78). In other words, the older the participants were, the shorter they rated their subjective distances to the future, and this finding applies to both the week and the month timescales.

The participants' subjective confinement scores also significantly affected their subjective temporal distances at both timescales (week: $F(1, 1,437) = 6.46$; $P = 0.01$; $\eta^2 = 4.47 \times 10^{-3}$; 95% CI, (−0.84, −0.11); month: $F(1, 14,846) = 16.84$; $P = 4.29 \times 10^{-5}$; $\eta^2 = 0.01$; 95% CI, (−1.24, −0.44); Fig. 3f,g). The more isolated the participants felt, the more distant their subjective future felt. Under the linear assumption, the most extreme increase in subjective confinement score (from 5 to 20) corresponded to an average difference of −7.09 on the subjective temporal distance scale for 'next week' (from 31.0 ± 1.34 s.e.m to 38.1 ± 1.95 s.e.m.) and of −12.6 for 'next month' (from 63.5 ± 2.15 s.e.m to 50.9 ± 1.48 s.e.m).

While the subjective distance to 'next week' was not significantly affected by stringency (F(1, 1,105) = 1.93; $P = 0.16$; $\eta^2 = 1.75 \times 10^{-3}$; 95% CI, (−0.03, 0.16); Fig. 3h), we observed an increase of the felt distance to 'next month' with an increase in stringency measures ($F(1, 1,165) = 8.54$; $P = 0.004$; $\eta^2 = 7.72 \times 10^{-3}$; 95% CI, (0.05, 0.25); Fig. 3i). Under the linear assumption, the most extreme increase in stringency (from 25 to 90) corresponded to an average difference of 9.88 on the participants' subjective temporal scale to 'next month' (from 49.7 ± 2.34 s.e.m to 59.6 ± 1.554 s.e.m.).

In brief, as was the case for the passage-of-time ratings, the participants' felt isolation affected nearly all measures of subjective temporal distances: the more isolated the individual felt, the further away temporal landmarks were rated at both timescales (week and month) and on both orientation measures (past and future). Also, while the objective mobility impacted past temporal distances at the week timescale, the objective stringency had an effect at the month timescale instead. Finally, and interestingly, at all timescales, age affected the participants' future but not past temporal distances.

Discussion

The COVID-19 pandemic is one of those rare historical episodes during which the entire world adopted comparable constraints on the human population at the same time. The initial measures against

COVID-19 were states of emergency and partial to full lockdowns. Here we report a database that provides tangible quantitative and qualitative assessments documenting a wide range of factors mediating the temporal distortions and disorientations experienced during this historical episode. Making the database and the online tools to collect additional data accessible is motivated by the observation that, as we write this paper, we have not yet returned to a global normality level. Our experimental tools have been and can be easily translated to additional languages, providing a stepping-stone for cross-cultural studies using multidimensional variables. We made efforts for the Blursday database to be accessible and readable to all researchers. We provide a graphical user interface that researchers without a programming background can use for parsing and retrieving the data as required by their research questions. We also include optional outcomes of some of our preliminary analyses as part of the data (for example, objective lockdown measures and subjective confinement indices).

Here we wished to highlight the existence of Blursday as well as showcase the reliability of the collected data on measures such as sleep disturbances and anxiety, and well-established empirical facts typically measured in laboratory settings (Supplementary Information). To this end, we provide a replication and extension of previously reported sleep disturbances and borderline anxiety during the first lockdown in France[36], showing that the questionnaires included in the database can be reliably exploited independently of research interests dedicated to timing research (Supplementary Fig. 4). A number of questionnaires in the database could be exploited on their own for epidemiology, demographics, psychiatry or chronobiology, or as covariates of other experimental measurements provided in the database. We also illustrate the distributions of several dependent variables in some of the timing tasks measured in Blursday, all of which point to the psychophysical and psychometric utility of our experimental approach for future investigations dedicated to these timing properties (Supplementary Fig. 5).

Importantly, by exploring the effects of stringency, mobility, subjective confinement, age and hour of day on several measures of subjective time (Table 2), we report empirical findings showing that both objective measures of lockdown and subjective measures of confinement influence the participants' time perception at different timescales.

We found that the participants' subjective confinement scores, designed to capture how isolated the participants felt, systematically accounted for changes in temporal orientation at the scale of a few days to a week and a month. Notably, the more isolated the participants felt, the slower time seemed to pass. This observation generalizes how feeling isolated contributes to temporal distortions and the felt slowing of the passage of time, which has been noted in a Brazilian study[25]. It also accounts for the diversity of passage-of-time changes reported during lockdown and attributed to possible consequences of isolation such as boredom[19–24]. Evaluating the degree to which participants felt isolated is thus an important psychological factor that provides additional insights on the participants' subjective well-being independent of the objective lockdown situation. Indeed, our analyses were applied to all sessions (in and out of lockdown) over months during which objective lockdown measures were difficult to track.

How isolated the participants felt consistently modulated their subjective assessment of past and future distances so that the more isolated individuals felt, the more distant in time past and future events seemed to be. These observations are essential in that temporal orientation is the ability to conceive of the self in subjective (past or future) time, an ability that has also been argued to be a core component of autonoetic consciousness[37]. We also found that the older the participants were, the closer their future appeared to be. Previous timing research has shown differences in the perception of past and current passage of time[38], but future-oriented prospective timing has received less attention in the literature, although it may entail differences in foresight across ages[39]. Indeed, ongoing work uses these measures together with participants' time perspective personality traits (ZTPI) to explore individuals' self-perception and the behavioural consequences of temporal disorientations on delay discounting (all collected measures in the Blursday database).

Two objective indices of lockdown (stringency and mobility) affected retrospective duration estimations in an intriguing way. It is now well-known that participants tested on a range of magnitudes display a behaviour that conforms to the predictions of a Bayesian observer. Most studies assess this by using a range of magnitudes around a value of interest showing a generalizable pattern of central tendency or regression to the means[26,28,40]. The central tendency is described as a subjective underestimation of values below the mean of the distribution and an overestimation of values above this mean. The range of durations calibrates the central value and thus the cut-off or the intersection between a presumed ideal observer (the identity line) and an individual's subjective magnitude estimates. Our observed retrospective duration estimations conformed to this typical central tendency pattern, otherwise known as Vierordt's law in timing research[27].

However, a key issue is that a classification as 'short' or 'long' does not have any reference point in our current study other than the prior belief of each participant. In Blursday, the range of retrospective durations explored was wide (from 1 min to 5 h) and uncontrolled since the duration was set by each participant's last log-in. Considering that each data sample was drawn from an independent observer tested on a different duration, the observation of a central tendency unexpectedly suggests the possibility of an indifference time interval (or absolute human prior) of about a quarter of an hour.

Historically, Woodrow[41] considered that the indifference interval should be defined not as the duration at which the individuals' average error is zero but instead as "the interval at which the average of all errors in any specified total distribution is zero". In other words, Woodrow posited the possibility of an absolute indifference interval. To demonstrate this, he tested participants using durations from ~300 ms to 4,000 ms and a temporal reproduction task; the temporal reproduction data showed a central tendency around ~600 ms. Each participant was tested several times, which could not test the initial hypothesis. Closer to our retrospective duration task, in which individual samples are independent, data in two later reports showed a possible central tendency between 16 and 50 min (ref. [42]) or between 2 and 3 min (ref. [43]). In Blursday, the large-scale dataset, the wide range of durations tested and the multi-cultural inclusion make this

Fig. 3 | Subjective temporal distances. a, Subjective temporal distances from the first day of lockdown as a function of the mobility index. The black dots are the mean subjective temporal distances binned by mobility. Their size scales with the underlying number of individual grey data points. The black line is a regression line estimated from the linear regression model; the 95% CI is shown with grey shading. **b**, Subjective temporal distances from the first day of lockdown as a function of the index of subjective confinement. **c**, The distribution of future subjective temporal distances obtained for 'next week' (light green) significantly differed from those obtained for 'next month' (dark green; $F(1, 3,169) = 1,171.9$, $P = 2.2 \times 10^{-16}$). **d,e**, Subjective temporal distances to 'next week' (**d**) and 'next month' (**e**) as a function of age. The light and dark green dots are the mean subjective temporal distances binned by age. Their size scales with the underlying number of individual grey data points. **f,g**, Subjective temporal distances to 'next week' (**f**) and 'next month' (**g**) as a function of the subjective confinement index. **h,i**, Subjective temporal distances to 'next week' (**h**) and 'next month' (**i**) as a function of stringency. The black lines are regression lines estimated from the linear model; the 95% CIs are shown with grey shading.
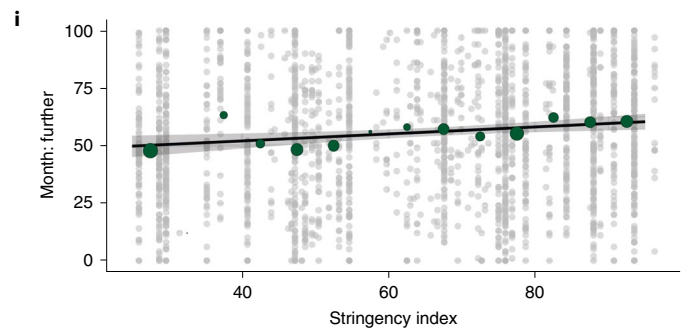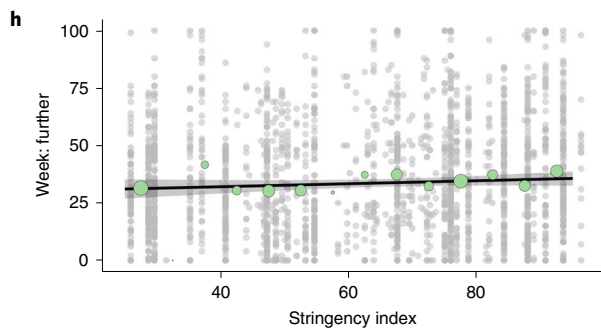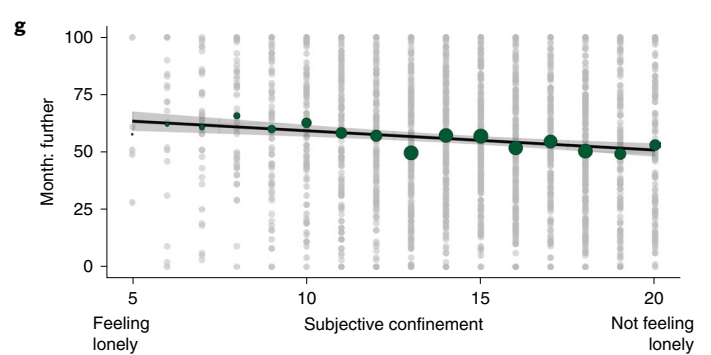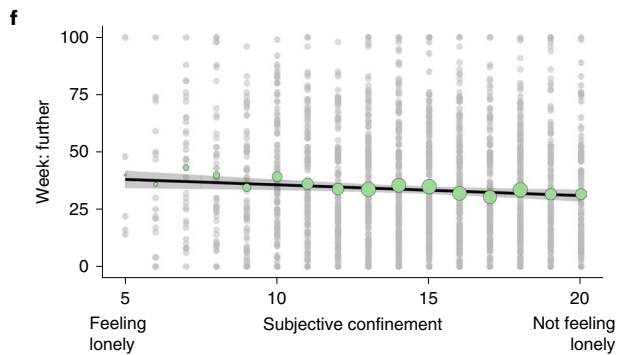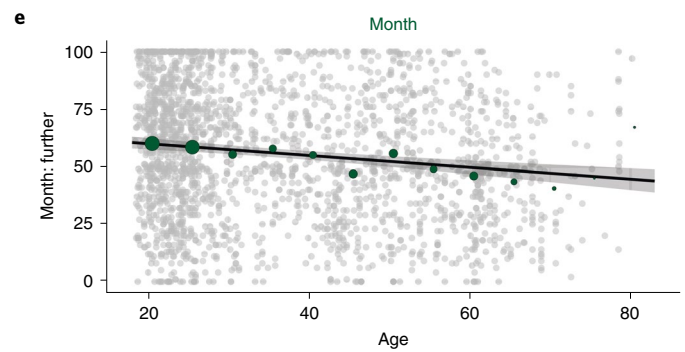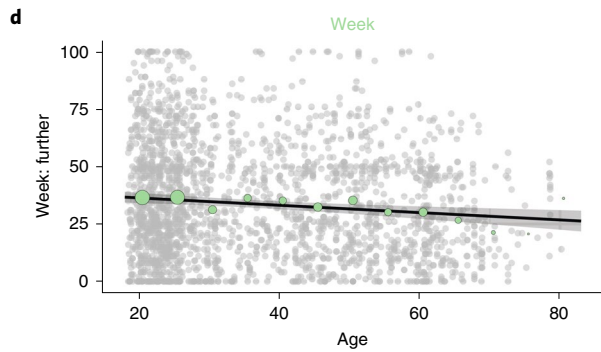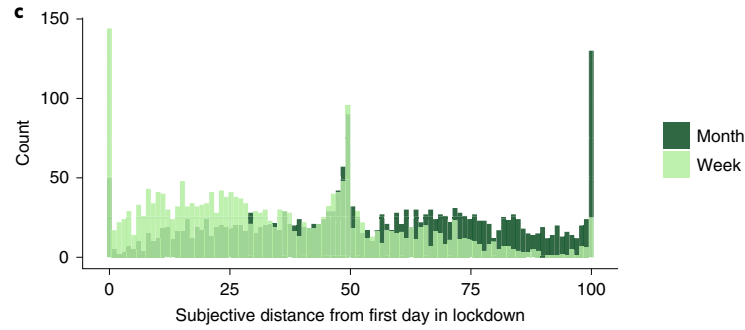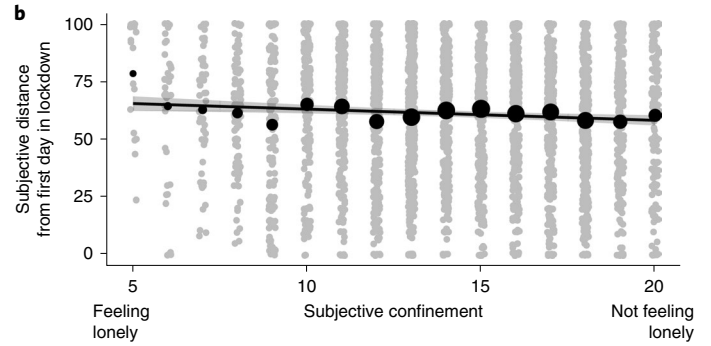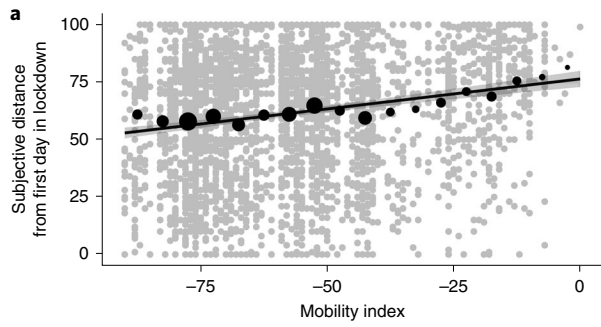
Table 2 | Summary of preliminary observations

Timescale	Orientation	Task	Objective stringency	Objective mobility	Felt confinement	Age	Time of day
Minutes to hours	Past	Retrospective duration	✓	✓	✗	✗	✗
Few days	Past	Passage of time	✗	✗	✓	✗	✗
Few days to weeks	Past	Subjective distance from first day of confinement	✗	✓	✓	✗	✗
Week	Future	Subjective distance to next week	✗	✗	✓	✓	✗
Month	Future	Subjective distance to next month	✓	✗	✓	✓	✗

To illustrate the use-value of the Blursday database, we selected only a few measurements testing the participants' time perception at different timescales (from minutes to one month) and orientations (past or future). We explored the effects of stringency (an objective index), mobility (an objective index), subjective confinement (the subjective isolation index), age and hour of day on distinct measures of subjective time. A check mark indicates a significant effect of the covariate on the time measurement ($P < 0.05$); an ✗ indicates an absence of a significant effect. The size and directionality of the effects are described in full detail in the Results section. This table summarizes otherwise more complex effects subjected to the limitation of our selection of relevant factors and choice of statistical models.

result distinctive—the observation of a central tendency towards 15 to 20 min at the inter-individual level is non-trivial. We can add to this that the central tendency for retrospective duration was significantly less pronounced during lockdown (S1) than outside of it (SC), so that the participants' reports were closer to the ideal observer and conformed less to Vierordt's law during lockdown than outside of it.

Finally, the highlighted observations by no means exhaustively exploit the varied repertoire of tasks, tests and questionnaires of the Blursday database. This stands as a limitation of our results, considering that we have not fully exploited the numerous factors that were recorded, which could help further disentangle their weighted contributions to the temporal distortions and disorientations we report. The Blursday database is amenable to cross-replication studies and feeds ongoing analyses testing specific working hypotheses. For instance, a cross-cultural analysis revealed differences in anxiety and depression that can be partially attributed to differences in individuals and cultural time perspectives[17]. The motor timing tasks, designed to assess whether endogenous rhythms, sensorimotor productions and synchronizations were affected during isolation, can be enriched with the personality traits collected on the same individuals as well as their demographics (age and gender). The foreperiod paradigm, which assesses implicit timing, is being explored with respect to some of the lockdown measures but also as a function of age, cultural diversity and self-perception measures. The assessment of temporal landmarks taps into the possible distortions of temporal cognitive maps induced by the COVID-19 episode in the population, thereby enabling the exploration of how temporal distortions may link to episodic memory and participants' fluency reports.

In conclusion, we are confident that the Blursday dataset will act as a systematic historical record of temporal disorientation and distortion during COVID-19 and can help future studies use and build on the same tools to assess the effects of social isolation on temporal information processing across cultures and post-pandemic. In this Resource article, we highlighted only a few possible observations drawn from the current dataset. Our study demonstrates the feasibility of an international study in a short time only thanks to the help of community builders such as the Timing Research Forum (http://timingforum.org). As members of the timing community, we hope that Blursday sets forth an international 'TimeLab' that can support and foster large-scale multi-cultural studies in timing and psychological time research.

Methods

This research was conducted in compliance with all ethical regulations ('Ethics').

Participants. As of 8 November 2021, a total of 2,840 participants had contributed to the online 'Time Social Distancing' study in 12 countries (Argentina, Canada, Colombia, France, Germany, Greece, India, Italy, Japan, Turkey, the United

Kingdom and the United States) and completed at least one full questionnaire or task in the study (Supplementary Table 1).

Full participation in the entire study entailed completing 14 questionnaires and three runs of 15 tasks in a given session (Table 1). The attrition rate was thus predictably very important in the course of the longitudinal study: 439 participants finished all tasks in S1 (Table 1 and Supplementary Fig. 1), conducted during the first lockdown; and 200 participants finished S2 and 244 finished S3, which took place about two weeks and three months after the initial lockdown confinement, respectively. In some countries (France and Italy) a shortened fourth session was conducted (S4) on the same participants during their second lockdown with 275 participants (the full count description per session per task/questionnaire and per country is available in Supplementary Table 1).

At least a year later, starting in May 2021, as restrictions started to be lifted in some countries, a control pool of naive participants was recruited in each country. As of 8 November 2021, 243 participants had completed the SC. This control population was tested on the full set of questionnaires and tasks originally tested in S1. As of 8 November 2021, these tests were finished in some countries (for example, France, Japan, Italy and Germany) and were ongoing (for example, Turkey) or planned (for example, Argentina and Greece) in others. For ease of reporting, we named this session the 'control session' to highlight that this pool of participants did not take part in the previous sessions (and hence were naive to the questionnaires and tasks) but also that they were tested outside the most severe series of lockdowns in the tested countries (France, Japan, Italy and Germany). However, we also contend that even as of March 2022, the world situation cannot be considered a control in a rigorous and empirical sense of the term. A rigorous control would require the same study to have been performed before the COVID-19 pandemic. While it is conceivable that some of the tasks and questionnaires we tested during the pandemic could find matching controls tested before the pandemic, no such data are currently part of the database. Hence, we loosely refer to this group of participants as 'control participants' and to the session as the 'control session' to emphasize, for instance, that learning effects and familiarity with the task in the longitudinal data can be controlled for. It is also noteworthy that our analysis takes into account a more nuanced approach to lockdown by using a continuous index of stringency as opposed to the categorical dichotomy of being in or out of lockdown adopted in the existing literature ('Assessment of objective and subjective confinement indices'). In all sessions, participants reporting drug usage and psychiatric disorders were a priori excluded from data collection; some of the included questionnaires otherwise allow for an evaluation of depression, stress, anxiety and attenuated symptoms of psychosis. Data from Colombia, the United Kingdom and the United States were too few to be included and were a priori discarded from most analyses (although they are made available in the database). Due to the exceptional nature and speed of change of governmental policies, the experiments started during the first lockdown or state of emergency of each country in 2020 (Supplementary Fig. 1) and continued longitudinally at different paces according to local policies. We report in Supplementary Fig. 1 the full demographics of the database during the experiments along with lockdown dates and general timelines of the study.

Statistics and reproducibility. We used a general linear modelling approach, using a single-level or multilevel (mixed) design where applicable. We used analysis of variance to assess the significance of all terms in the models. Multiple (post-hoc) testing was not applied, and no multiple comparison corrections were needed. No statistical methods were used to predetermine sample size. We removed aberrant and outlier data points from the analyses, as explained in the section 'Outliers in reported analyses'. The investigators did not interact with the participants, and no blinding procedure was employed. The presentation of tasks and questionnaires was pseudo-randomized across participants using the Latin Square option in Gorilla.

Outliers in reported analyses. In the retrospective duration analysis, we used three criteria for defining outliers. The first criterion rejected data points with a clock duration shorter than 1 min and longer than 5 h due to the implausibility of these timings in our study protocol. The second criterion excluded data with subjective retrospective durations shorter than 12 s and longer than 25 h (that is, subjective estimates that were 0.2 times the shortest possible clock duration and 5 times the longest possible clock duration). The last criterion removed data points with relative duration errors (computed as (retrospective duration estimation − clock duration)/clock duration) beyond the central 95th percentiles per country and per session. The application of these criteria discarded 8.8% of the original dataset.

The passage-of-time ratings used data collected right after the retrospective duration estimation. For this reason, we considered that trials in which the clock duration responses were aberrant were also unreliable for the passage of time. We therefore applied the same criteria and rejected passage-of-time trials in which the reported clock duration was shorter than a minute or longer than 5 h, as well as trials in which the clock duration was beyond the central 95th percentiles. The application of these criteria discarded 8.3% of the original dataset.

We performed no outlier removal for the analyses of subjective temporal distance (next week or month) beyond missing responses, which were discarded on a per-trial basis.

For all VAS measures (passage of time and subjective temporal distances; Fig. 2a and Fig. 3c, respectively), the extreme and middle responses of the VAS tended to be over-represented. Since we had no clear criterion to distinguish whether such values indicated a misuse of the VAS scale, we did not exclude them.

Ethics. All participants were provided with full instructions and signed an online consent form following the Declaration of Helsinki (2018) and the rulings of ethical committees. The participants were provided with a contact email in case they had any questions before proceeding. The approval to run the study internationally was obtained from the University Paris-Saclay (CER-Paris-Saclay-2020-020; all countries). Whether seeking ethical approval in each country was required and sufficient to run an international online (non-interventional) human study is an unresolved question[44]. In Colombia, in accordance with the provisions of Resolution 8430 of 1993 of the Ministry of Health (through which the scientific, technical and administrative standards for health research are established), the ethics committees of the institutions where the research is carried out approve the research protocols and are responsible for compliance. As CER-Paris-Saclay-2020-020 approved the research protocol carried out during the COVID-19 pandemic, we did not have to request more permits or endorsements in Colombia. The Ethics Committee at Panteion University of Social and Political Sciences came into force on 28 July 2021 (law). All data in Greece were collected prior to this date. The study was thus run according to the provisions of Greek law (νόμος 4521/2018). For the control data, which will be acquired in the future and thus after 28 July 2021, ethical approval has been sought from the local ethical committee. Other principal investigators sought local ethical approval for each country: Comité de Etica de la Universidad Nacional de Quilmes CE-UNQ No. 2/2020 (Argentina); Université Laval, 2020-114 / 14-04-2020 (Canada); Institute for Frontier Areas of Psychology and Mental Health, Freiburg, IGPP_2020_01 (Germany, Switzerland and Austria); Ethical Committee for the Psychological Research of the University of Padova (Italy); Institutional Ethics Committee, Indian Institute of Technology Kanpur, IITK/IEC/2019-20/18-Apr-20/I (India); the Institutional Review Board of the University of Tokyo, No. 705 (Japan); UCLA Office of the Human Research Protection Program, IRB No. 20-000612 (United States); and Koç University, 2020.113.IRB3.053 (Turkey).

Data acquisition procedure. We used the Gorilla Experiment Builder (www.gorilla.sc) to build and host our study[45] in several languages and countries. The original project was designed in English. French, Japanese, Italian, Greek, Portuguese, German, Spanish and Turkish were cloned from the original English templates, translated and beta-tested by the local teams, and eventually adapted to the needs or cultural specificities of each country. All questionnaires and tasks are freely accessible in English (and other languages; see below) under the Gorilla Open Materials Attribution-NonCommercial Research-Only licensing: https://app.gorilla.sc/openmaterials/278377.

In most countries, participants were recruited by means of general advertisement using institutional newsletters and/or outside the institution through social media channels. In Japan, participants were recruited through an agency or online (half of the participants for the SC); all participants were given monetary rewards for completing each session. In France, the control participants were given the option to receive a small compensation for their participation (80 of 184 participants asked to receive compensation). In Turkey and Greece, a group of participants was recruited through classes and compensated with bonus course credits.

General information was provided in different languages and updated over time for each country on a specific web page (https://brainthemind.com/covid19/) as well as locally in printed form (https://osf.io/359qm/)[46]. When the participants connected to the protocol website, they were first provided with general information about the study and asked to provide their consent. They were then invited to create an anonymized public identification, which they kept

for the rest of the study. The participants could leave the website and come back where they had stopped at any time. They were free to stop the experiment when they wanted to. Any technical issue, bug or problem that the participants had was handled by email.

Protocol. The full experimental protocol consisted of three or four longitudinal sessions (S1, S2, S3 and S4) and one control session (SC, new participants). In all sessions, the participants first went through a series of questionnaires administered in a random order across participants, most of which they had to take once per session. After the series of questionnaires, they entered a series of diverse behavioural tasks presented in pseudo-random order (latin-square design) across participants. Each task was presented up to three times within a session. In the course of the study, the number of runs was reduced to lighten the requirements of the study. An overview of the full session is described in Supplementary Fig. 2 and Table 1. Both provide a comprehensive description of the content of each session. A detailed description of the questionnaires and tasks used in the study is provided below.

Questionnaires. We included a number of questionnaires that have been (cross-)validated in different languages and in several countries as well as designing new ones. Answering the first series of questionnaires took about an hour. We designed a Confinement Tracker questionnaire and an Isolation Questionnaire adapted to the circumstances to provide basic information on the state of lockdown (Supplementary Information). We included the UCLA Loneliness Scale[47,48], which provides several metrics of self-reported loneliness. The clinically oriented HADS[49] provides reliable measures of the state of anxiety and depression of participants. The PQ16 (ref. [50]) was used to screen the participants' attenuated symptoms of psychosis. Mindfulness was assessed using the Freiburg Mindfulness Inventory[51]. Circadian preferences and sleep disturbances were assessed using the Morningness–Eveningness Questionnaire reduced version or rMEQ[52], the ultra-short version of the Munich Chronotype Questionnaire or µMCTQ[53], monthly and weekly versions of the PSQI[54,55], and a daily sleep quality questionnaire (Supplementary Information). The general personality traits of the participants were assessed using the BFI-10 (refs. [56,57]). The ZTPI[58,59] provides a general assessment of individuals' temporal orientation traits[60]. The attentional orientation traits of the participants were assessed using the ASQ[61,62]. An analysis of sleep disturbances (PSQI) and anxiety (HADS) in the French subsample of data collected in Blursday replicates previous findings and is fully described in Supplementary Fig. 4.

Tasks. *Retrospective duration.* The vast majority of studies in time perception use prospective timing tasks in which the participants know beforehand that they will be asked to estimate the duration of an upcoming event or stimulus[63]. While helpful (see below for prospective duration tasks), this paradigm also falls short of capturing temporal judgements that are commonly made retrospectively in daily life. Retrospective temporal judgements require individuals to estimate the elapsed time since a past event or during an activity that just happened without them knowing a priori that they will have to time[29,63–65]. Cognitive components (for example, attention and memory) are considered to be differentially involved during retrospective versus prospective timing[63], with retrospective duration estimates assumed to engage episodic memory processes. In the Blursday project, we included retrospective duration estimations (Supplementary Fig. 3) at several moments after a series of questionnaires or after specific tasks. Here we report the first retrospective duration estimate that the participants had to make in the study, which followed a series of initial questionnaires and thus spanned a scale of minutes to hours. The outcomes are included in the Results section and illustrated in Fig. 1.

Passage-of-time judgements. Passage-of-time judgements can be used to estimate the subjective feeling that time passes, otherwise commonly referred to as the 'flow of time'[34,66]. In this study, passage-of-time judgements were implemented either as VASs ranging from 'very slow' to 'very fast' or as Likert scales offering a categorical choice among 'very slow', 'slow', 'normal', 'fast' and 'very fast'. As for the retrospective duration estimates, we used passage-of-time judgements after several tasks during the study by asking the participants to report how fast time felt in a given lapse of time (for example, Supplementary Fig. 8). We report the passage-of-time judgements that were estimated using a VAS and over the scale of the 'last few days' (Supplementary Fig. 3) in the Results section.

Temporal landmarks and event recording. By analogy to spatial landmarks, temporal landmarks are salient events that have been time-stamped in memory. For instance, one's birthday tends to be an important landmark. One way to assess the existence of temporal landmarks is to evaluate the speed (response time) and ease (error rate) with which one answers a question about a point in time. Chronometry and performance can be driven by the psychological distance of that point in time from the operative landmark in one's temporal cognitive map. Temporal landmarks can be culturally and autobiographically idiosyncratic. For instance, when participants are asked to answer as fast and as accurately as possible "What day is it?", the closer a day is to a cultural temporal landmark (for example, Sunday in Catholicism or Shabbat in Judaism), the faster the responses and the lower the error rates[67,68]. In this study, we prompted the participants at various times with the question "What day is it today?" and asked them to report an important event for them on that

same day (Supplementary Fig. 3). The distributions of the collected response times during lockdown in all participating countries are illustrated in Supplementary Fig. 5d.

Subjective temporal distance. An estimation of subjective temporal distance involves asking participants to estimate how far away an event feels for them. Subjective temporal distances involve episodic memory processes and the abstraction of temporal relations between events[69,70]. Here we asked the participants to use a VAS to report how far away their first day of lockdown felt with respect to the moment at which they were asked this question (that is, the present). This subjective temporal distance provides a subjective measure of elapsed time at the scale of days to weeks and months as recalled by the participant (Supplementary Fig. 3). We also assessed the participants' subjective distance to a week and a month ahead, to test their future orientation. Although subjective distances may be related to the actual passage of time, people may feel more or less close to a past event regardless of its actual temporal distance[71]. The outcomes of these ratings are included in the Results section and illustrated in Fig. 3.

Fluency tasks: semantic, phonemic and timescales. Verbal fluency tasks involve reporting as many words as possible within an imparted lapse of time, on the basis of phonemic or semantic criteria[72]. These tasks were originally developed for neurolinguistic and cognitive assessments. For instance, a semantic fluency task can consist of asking participants to report as many animals as possible in 60 s; this was the semantic fluency task included in our study (Supplementary Fig. 6). Similarly, the phonemic fluency task consisted here of reporting as many words as possible starting with the letter 'P' in 60 s. In addition to classic verbal fluency tasks, we included past and future event fluency tasks to assess the accessibility of mental representations of life events that the participants had experienced in the past or that they planned for the future[73]. These fluency tasks took the form of the prompt "Write as many events as possible that occurred last [week/month/year]" for past fluency or "that will happen next [week/month/year]" for the future fluency task (Supplementary Fig. 6). Hence, these fluency tasks tested the scales at which fluency was assessed—namely, over a week, a month or a year. An additional semantic fluency task inquiring about associations with the word 'time' was tested by simply asking the participants to report as many spontaneous associations as possible that they had with this word. All fluency tasks in the Blursday database were 60 s long, and the number of collected items was unlimited.

Prospective duration estimation while counting up or down. When participants prospectively estimate a lapse of time, both attention and working memory influence their duration estimates. The demonstration of this influence is often based on a dual-task paradigm in which a participant is asked to perform both a temporal and a non-temporal task. Several non-temporal tasks have been used to show the impact of attention or working memory on prospective judgements of time[74–76]. One possibility is to ask participants to perform a counting task[74], a strategy that is adopted in the present investigation. The participants were prompted with a prime number and asked to count up (addition) or down (subtraction) in steps of 3 or 7 as a way to control the difficulty of the task (Supplementary Fig. 7). Following a trial, the participants were asked to report the number they had reached as well as the amount of time spent doing the task (which could be, unbeknownst to the participants, either 12 s or 24 s).

Prospective duration estimation while performing an n-back task. The level of processing in working memory lengthens temporal production, presumably by slowing down temporal integration[77]. One means to further explore the influence of working memory on time estimation is to use a parametrically variable *n*-back task in which a sequence of letters is displayed on the screen and participants decide on a trial-by-trial basis whether the displayed letter is identical to the previous one ($n=1$) or to the one two letters before it ($n=2$) and so on. It has recently been shown that increasing the working memory load (increasing *n*) may proportionally shorten the prospective estimation of duration, whereas paying attention to time may lengthen it in an additive fashion[78]. In this study, we asked the participants to perform an *n*-back task ($n=1$ or $n=3$) and to report how long the trial was (in minutes:seconds) as well as how fast time felt on a Likert scale. Unbeknownst to the participants, a trial could last 45 s or 90 s (Supplementary Fig. 8).

Duration production and metacognition. Duration production is another prospective timing task that consists of asking participants to estimate a time interval using overt motor behaviour. Here the participants were asked to produce 3.6 s by pressing the spacebar to initiate their time estimation and, once they considered that 3.6 s had elapsed, pressing the spacebar again (Supplementary Fig. 9). Following each duration production, we asked the participants to assess their performance (which constitutes a metacognitive judgement task) and provide an assessment of temporal error monitoring[79,80]. In temporal production tasks, the substantial variability within individuals that is observed is assumed to result from the endogenous timing uncertainty between trials. The statistical features of this timing variability and its relation to the time intervals being judged have been primary focuses of the psychophysical study of interval timing[81]. The fact that organisms can access their level of endogenous timing uncertainty as a form

of temporal metacognition[79,80] might serve optimal temporal decisions in animals and humans[82]. Hence, this metacognitive assessment of temporal judgements was included here by asking the participants to not only evaluate the signed error magnitude of their temporal production (using a VAS) but also rate their confidence either in their temporal production (Turkey) or in their metacognitive judgement (most countries). The descriptive statistics of the duration productions for all participating countries in S1 are illustrated in Supplementary Fig. 5b.

Spontaneous finger tapping (free tapping). Spontaneous motor tempo (that is, the rate at which an individual taps in the absence of any timing cue) is universally situated between around 1 Hz and 4 Hz with a bimodal or even trimodal distribution of the intertap intervals (ITIs) (with peaks at around 250, 500 and 1,000 ms)[83]. The rate at which participants tap is assumed to reflect the speed or the period of a still largely unknown timekeeper, and it has been shown to be sensitive to alterations such as ageing[84,85]. It has been argued that this is because spontaneous tapping tasks are too simple to be compensated by alternative compensatory mechanisms—that is, they are not cognitively penetrable[86]. Basic information about the task is provided in Supplementary Fig. 10. The descriptive statistics of the ITIs for all participating countries in S1 are illustrated in Supplementary Fig. 5a. A quantitative comparison of ITIs by browser and operating system is provided in Supplementary Fig. 11.

Synchronization–continuation. In the field of motor timing, the classical synchronization–continuation paradigm[87] consists of asking participants to synchronize their finger tapping with an auditory metronome and then continue finger tapping with a sequence of constant intervals at the pace they initially synchronized with[88]. In the continuation phase, the variability of the ITIs is the key dependent variable of interest[88]. When the stimulus period is varied parametrically, an autocorrelation analysis of the series of produced intervals can be used to sort out the part of observed variability due to the temporal component of the task (associated with the underlying timing mechanism) and the part due to the implementation of the intervals with finger taps (the motor component). The synchronization phase, also known as paced finger tapping, is one of the simplest tasks to study sensorimotor synchronization, which has been argued to capture the ability of coordinating one's own movement with an external metronome[89]. In paced finger tapping, the asynchrony (the time difference between the response and the stimulus) is the fundamental variable of interest[90], both for isochronous and for perturbed sequences[91]. A succinct illustration of the task used in the study is provided in Supplementary Fig. 12. We tested two conditions: tapping in sync or out of sync with the stimuli. The measured asynchronies in the synchronization task and the ITIs in the continuation task during lockdown are illustrated in Supplementary Fig. 5a for all participating countries. A quantitative comparison of timing by browser and operating system is provided in Supplementary Figs. 13 and 14.

Foreperiod paradigm and implicit timing. The implicit extraction of temporal regularities from the environment allows people to form temporal predictions and orient attention to particular moments in time[92], which can lead to more efficient behaviour, such as faster response times or improved perceptual sensitivity[93,94]. Here we implemented an implicit timing task (Supplementary Fig. 15), in which we varied the foreperiod (the time interval between the cue and the target tone), such that the duration was either fixed (hence predictable) or variable (non-predictable) throughout a block, and we measured response times as an index of efficient temporal prediction. The measured reaction times in S1 for all participating countries are illustrated in Supplementary Fig. 5c. A comparison of reaction times by browser and operating system is provided in Supplementary Fig. 16.

Delay discounting. Delay discounting refers to the devaluation of the reward amount as a function of its receipt[95], making both the amount and the proximity of the reward important factors in determining the choice behaviour of participants when they are asked to choose between two options. Some individuals may prefer the immediate reward over a delayed reward even when the amount offered immediately is substantially less than the amount offered after a delay (for example, preferring to receive US$5 now over receiving US$20 in a year). Confinement typically leads to boredom, which can trigger impulsivity[96]. In this task (Supplementary Fig. 17), different amounts were offered to the participants at different delays to estimate the subjective values of the offers as a function of time required to collect them. The amounts for each country were adjusted according to the purchasing power parities (OECD data, retrieved 20 September 2019 from https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm; ref. [97]).

Self-preference. Phenomenological approaches have related time with self since as early as the twentieth century[98], leading psychiatrists to link time with disorders of the self in psychosis[99–101]. Such a link has been evidenced experimentally[102,103]. In addition to the PQ-16 questionnaire exploring attenuated psychosis, the self-preference task was added to provide an objective self-related measure. It has repeatedly been shown that a stimulus we associate with ourselves is processed faster and with higher accuracy than a stimulus we associate with others[104,105]. These effects can be accounted for either by a self-referent memory advantage[106] or by enhanced attention drawn to self-related information[107]. To test this, and

in accordance with previous work, we used a reaction time task in which the participants learn to associate a geometrical shape with a label ('Self', 'Friend' and 'Other'; Supplementary Fig. 18). On subsequent trials, the participants are presented with one shape and one label, which may or not match the previously learned associations. The participants had to report as fast and as accurately as possible whether the shape and the label matched.

Assessment of objective and subjective confinement indices. The diversity of questionnaires included in the study provides a resource for numerous proxies of lockdown and subjective confinement indices. Here we illustrate four possible approaches illustrating the severity of lockdown experienced by an individual, objectively, semi-objectively and subjectively.

A first objective measure (by country) is the Stringency Index derived by Our World in Data[108]. The Stringency Index is a composite measure of nine governmental response indicators that include school closures, workplace closures and travel bans, rescaled to values ranging from 0 to 100, with 100 being the strictest stringency. A second objective measure (by country) can be found in the Google mobility index measures during COVID-19 (ref. [109]). For the purpose of our concise report, we selected the Transit Station Mobility Index (referred to as the mobility index), which quantifies how much time visitors spent in various transit stations (subway, taxi stand and rentals) during a selected period relative to a baseline period. In the Google dataset, the baseline was defined as the median value from a five-week period spanning 3 January to 6 February 2020. The more negative the mobility index, the less mobility compared with the baseline. As is visible in Supplementary Fig. 1, while sessions were carefully aligned to the governmental lockdowns and state-of-emergency rules, they do not strictly map to the level of stringency or to the degree of mobility estimated in a given country. Some of our results and analyses indicate that objective measures of stringency and mobility may be adequate covariates to explore the effect of lockdown on behaviour (for instance, see the outcomes of our retrospective duration analysis above).

A third measure of lockdown is the number of days the participants reported being stranded at home in our confinement tracker. Although the verbal reports of the participants could be used as an objective measure, this estimation is prone to subjective factors such as memory[110], idiosyncratic and cultural biases[68,111], and variable temporal orientation towards socially meaningful events[112]. Hence, the reported number of days in lockdown cannot be considered a veridical and objective measure of lockdown, but it can minimally provide a fair and subjective approximation of it. The degree of deviance of the subjective measure with the veridical day of confinement can be compared to the locally applicable rules and official dates of lockdown for each participant, although uncertainty as to each individual case remains. Hence, the reported number of days in lockdown is considered a semi-objective measure.

Fourth, we defined a measure of subjective confinement based on the participants' self-assessed feeling of being isolated. Of the 20 items that we tested using the full UCLA questionnaire[47,48], we used the ratings of only 5 items that could be directly related to the consequences of lockdown and stringency measures. We made a proxy for the feeling of confinement using these 5 selected items: "I have nobody to talk to", "I lack companionship", "I feel completely alone", "I feel starved for company" and "I feel isolated from others". Answers to these questions were obtained using a four-level Likert scale. While objective measures of confinement captured the situation well, large inter-individual variability may subsist in participants' subjective feeling of having to stay home, being fully confined or being under various stringency rules. This could be due to factors such as personality traits (which can be assessed with the BFI included in Blursday) or social isolation (which can be explored with the remaining items of the UCLA questionnaire and various questions such as changes in social media use, the number of people in the household and changes in habits included in Blursday). For this concise report, we chose a direct and minimal approach using a confirmatory factor analysis, which showed that responses to the five items selected a priori could be aggregated along two dimensions, which we refer to as 'self-reported loneliness' (capturing responses to the statements "I have…" and "I lack…") and 'felt loneliness' (capturing responses to "I feel…"). These dimensions are available in the database, but for simplicity, we combined these two estimates of loneliness as a proxy for subjective confinement, which scored between 5 (feeling very isolated) and 20 (not feeling isolated).

We integrated the objective lockdown states and subjective confinement measures in the Blursday database as an optional feature of data downloading. Above, we use these measures as covariates and illustrate their impact on subjective time in the sampled population.

Reporting summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability
Our databasing approach follows the FAIR principles[113] stipulating findability, accessibility, interoperability and reusability of the data. In line with FAIR, we provide a graphical user interface to researchers, allowing them to easily and conveniently parse the data in a way that best fits their research needs (https://dnacombo.shinyapps.io/Blursday/). The data collected from each task and questionnaire are available at the individual trial/item level per participant in the database and will be incremented with quantified estimates per participant as analyses progress. The individual trial data are given to support modelling efforts that typically consider trial-based data sometimes on the basis of the order of their occurrence. Due to the nature of the tasks, reliable timing is an important factor. To help researchers estimate the degree of timing uncertainty in data collected online[114], we provide the participant's operating system and browser information with which the data were collected. To improve the readability of the data at this level of presentation, we also provide human-readable readme.txt files for each questionnaire and task in a dedicated OSF repository[46] (https://osf.io/359qm/ in folder Study_design/README/) along with additional sources of information that facilitates the reusability of the data. The OSF repository provides a public access platform to published materials, guides and codes associated with the Blursday database (https://osf.io/359qm/; ref. [46]). The OSF hub will be updated and incremented as results using the database get published. Readme files are provided describing the independent and dependent variables for each task, the number of trials and the number of possible runs. We provide a comprehensive listing of translation and associated references for the validation of the questionnaires used in Blursday. Additional resources such as the dates of the sessions, the timelines or useful resources for a more detailed assessment of local governmental measures are also provided.

Code availability
The code is available at Github.com (https://github.com/dnacombo/TimeSocialDistancing). The live server is available on Shinyapp.io (https://timesocialdistancing.shinyapps.io/Blursday/), and the source code is available at https://github.com/dnacombo/TSDshiny. The licensing of the database is CC BY 4.0. All questionnaires and tasks used in the Blursday study are accessible as Open Materials in Gorilla in English (https://app.gorilla.sc/openmaterials/278377), French (https://app.gorilla.sc/openmaterials/27809), Greek (https://app.gorilla.sc/openmaterials/281196), Turkish (https://app.gorilla.sc/openmaterials/286114) and Japanese (https://app.gorilla.sc/openmaterials/286482).

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Author contributions

Competing interests

Additional information

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Reporting Summary

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Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
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☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	We used the Gorilla Experiment Builder (www.gorilla.sc) to create and host our experiment (Anwyl-Irvine, Massonnié, Flitton, Kirkham & Evershed, 2018). All questionnaires and tasks used in the Blursday study are accessible as Open Materials on the website. English (https://app.gorilla.sc/openmaterials/278377); French (https://app.gorilla.sc/openmaterials/27809); Greek (https://app.gorilla.sc/openmaterials/281196); Turkish (https://app.gorilla.sc/openmaterials/286114); Japanese (https://app.gorilla.sc/openmaterials/286482)
Data analysis	Code for the analysis found in the paper are available here: https://github.com/dnacombo/TimeSocialDistancing

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

https://timesocialdistancing.shinyapps.io/Blursday/
Source code: https://github.com/dnacombo/TSDshiny

From MS:

Data availability statement
Our databasing approach follows the FAIR principles 111 stipulating Findability, Accessibility, Interoperability, and Reusability of the data. In line with FAIR, we provide a graphical user interface to researchers, allowing them to easily and conveniently parse the data in a way that best fits their research needs (https://dnacombo.shinyapps.io/Blursday/). Data collected from each task and questionnaire are available at the individual trial/item level per participant in the database and will be incremented with quantified estimates per participant as analyses progress. The individual trial data are given to support modeling efforts that typically consider trial-based data sometimes based on the order of their occurrence. Due to the nature of the tasks, reliable timing is an important factor. To help researchers estimate the degree of timing uncertainty in data collected online 112, we provide the participant's operating system and browser information with which data were collected. To improve the readability of the data at this level of presentation, we also provide human-readable readme.txt files for each questionnaire and task in a dedicated OSF repository (https://osf.io/359qm/ in folder Study_design/README/) along with additional sources of information that facilitates the reusability of the data.

Project repository on OSF.io
The OSF repository provides a public access platform to published materials, guides, and codes associated with the Blursday database (https://osf.io/359qm/). The OSF hub will be updated and incremented as results using the database get published. Readme files are provided describing the independent and dependent variables for each task, the number of trials, and the number of possible runs. We provide a comprehensive listing of translation and associated references for the validation of the questionnaires used in Blursday. Additional resources such as the dates of the sessions, the timelines, or useful resources for a more detailed assessment of local governmental measures are also provided.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☒ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Mixed-methods consisting of 14 questionnaires and 15 behavioral tests
Research sample	As of June 10th 2022, a representative sample of 2,840 participants participated in the online "Time Social Distancing" study in 9 countries. The study sample was not determine a priori and as extensive as possible within the imparted limits of the lockdowns.
Sampling strategy	Data sampling relied on country-wide lockdown policies and were for convenience.
Data collection	Data collection was realized online in each country. The experimenters were not blinded as to the experimental condition or the working hypothesis.
Timing	AR = Argentina; CA = Canada; CO = Colombia; DE = Germany; FR = France; GR = Greece; IT = Italy; JP = Japan; TR = Turkey Countries for which no control session has been collected are planning to collect data when the pandemic situation is back to "normal". Hence, we expect the database to grow. Session 1 AR 2020/05/11 2020/10/17 Session 1 CA 2020/04/27 2020/06/10 Session 1 CO 2020/04/30 2020/06/10 Session 1 DE 2020/04/20 2020/06/01 Session Control DE 2021/06/09 2021/11/08 Session 1 FR 2020/04/06 2020/06/01 Session 2 FR 2020/05/11 2020/08/04 Session 3 FR 2020/08/30 2020/10/28 Session 4 FR 2020/11/16 2020/12/14 Session Control FR 2021/5/26 2021/07/04

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Session 1 GR 2020/04/16 2020/05/05
Session 2 GR 2020/05/03 2020/10/08
Session 3 GR 2020/08/11 2020/11/08
Session 1 IN 2020/04/22 2020/06/06
Session 1 IT 2020/04/04 2020/05/20
Session 2 IT 2020/05/05 2020/07/03
Session 3 IT 2020/09/08 2020/11/15
Session 4 IT 2020/11/20 2020/12/30
Session Control IT 2021/04/27 2021/07/30
Session 1 JP 2020/04/20 2020/05/26
Session 2 JP 2020/06/08 2020/07/07
Session 3 JP 2020/09/23 2020/10/23
Session Control JP 2021/07/01 2021/07/21
Session 1 TR 2020/04/21 2020/06/10
Session 2 TR 2020/06/10 2020/09/17
Session 3 TR 2020/09/27 2020/01/06
Session Control TR 2021/06/22 ongoing
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Data exclusions

In all sessions, participants reporting drug usage and psychiatric disorders were a priori excluded from data collection.

Non-participation

The attrition rate was predictably very important in the course of the longitudinal study: 439 participants finished all tasks in the first session (S1; Table 1; Supp. Fig. 1; Supp. Table) conducted during the first lockdown; 200 participants finished the second session (S2) and 244 the third session (S3) which took place outside the initial lockdown confinement and about 2 weeks and 3 months after it, respectively. In some countries (France and Italy) a shortened fourth session was conducted (S4) on the same participants during their second lockdown with 275 participants. At least a year later, starting in May 2021, as restrictions started to be lifted in some countries, a control pool of naïve participants was recruited in each country. As of June 10th 2022, 243 participants completed the control session.

Randomization

All tests and questionnaires were presented in a pseudo-randomized manner using a latin-square designed between participants of the same country within the same session.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	Antibodies
☒	Eukaryotic cell lines
☒	Palaeontology and archaeology
☒	Animals and other organisms
☐	☒ Human research participants
☒	Clinical data
☒	Dual use research of concern

Methods

n/a	Involved in the study
☒	ChIP-seq
☒	Flow cytometry
☒	MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics

See above

Recruitment

In most countries, participants were recruited by means of general advertisement using institutional newsletters and/or outside the institution through social media channels. In Japan, participants were recruited through an agency or online (half of the participants for the control session); all participants were given monetary rewards for completing each session. In France, participants in the control session were given an option to receive a small compensation for their participation and ~43% of them chose so (80 out of 184 participants). In Turkey and Greece, a group of participants was recruited through classes and compensated with bonus course credits.

Ethics oversight

All participants were provided with full instructions and signed an online consent form following the Declaration of Helsinki (2018) and the ruling of Ethical committees. Participants were provided with a contact email if they had any questions before proceeding. The approval to run the study internationally was obtained from the University Paris-Saclay (CER-Paris-Saclay-2020-020; all countries). Whether the ethical approval obtained in the main PI's country is sufficient to run an international online (non-interventional) human study is an unresolved question 44. In this context, each PI sought local ethical approval for each country: Comité de Etica de la Universidad Nacional de Quilmes CE-UNQ No 2/2020 (Argentina); Université Laval, 2020-114 / 14-04-2020 (Canada); Institute for Frontier Areas of Psychology and Mental Health, Freiburg, IGPP_2020_01 (Germany, Switzerland, Austria); Ethical Committee for the Psychological Research of the University of Padova

(Italy); Institutional Ethics Committee, Indian Institute of Technology Kanpur, IITK/IEC/2019-20/18-Apr-20/I (India); The Institutional Review Board of the University of Tokyo, #705 (Japan): UCLA Office of the Human Research Protection Program, IRB#20-000612 (USA); Koç University, 2020.113.IRB3.053 (Turkey).

Note that full information on the approval of the study protocol must also be provided in the manuscript.