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Does time extend asymmetrically into the past and the future? A multitask crosscultural study

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Abstract

Does temporal thought extend asymmetrically into the past and the future? Do asymmetries depend on cultural differences in temporal focus? Some studies suggest that people in Western (arguably future-focused) cultures perceive the future as being closer, more valued, and deeper than the past (a future asymmetry), while the opposite is shown in East Asian (arguably past-focused) cultures. The proposed explanations of these findings predict a negative relationship between past and future: the more we delve into the future, the less we delve into the past. Here, we report findings that pose a significant challenge to this view. We presented several tasks previously used to measure temporal asymmetry (self-continuity, time discounting, temporal distance, and temporal depth) and two measures of temporal focus to American, Spanish, Serbian, Bosniak, Croatian, Moroccan, Turkish, and Chinese participants (total $N = 1,075$). There was an overall future asymmetry in all tasks except for temporal distance, but the asymmetry only varied with cultural temporal focus in time discounting. Past and future held a positive (instead of negative) relation in the mind: the more we delve into the future, the more we delve into the past. Finally, the findings suggest that temporal thought has a complex underlying structure.

Keywords: cross-cultural studies; self-continuity; temporal asymmetry; temporal depth; temporal distance; time discounting; temporal focus

1. Introduction

It is common to think that we move in time away from the past and toward the future (Horwich, 1987). The interest in the future is so psychologically central for many of us

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that Seligman et al. (2016) coined the term *Homo prospectus*. However, at the same time, humans have a *historical consciousness* (Rüsen, 2004), which reaches back into the past, allowing a person to understand their own identity or to plan and set goals for the future (Karniol & Ross, 1996). Overall, this suggests that the way people perceive the past and the future is interrelated. For example, our future self-image depends on how we remember our past self (Markus, 1977); our estimation of the probability that an event will occur in the future depends on how we perceive a similar event in the past (Si, Wyer, & Dai, 2016); and the value we give to expected future events depends on the value we gave to similar events in the past (Wirtz et al., 2003).

Still, does the future feel closer than the past? Does the future feel more valuable and more similar to the present than the past or does the asymmetry favor the past instead? Or maybe people adjust to objective reality and conceptualize past and future symmetrically? In a nutshell, the central question that we set out to answer is: do people conceptualize the future and the past symmetrically or asymmetrically?

Some studies have supported a future asymmetry in temporal thought (see Supplementary Table S1 for a detailed breakdown of studies, samples, tasks, and results). For example, Caruso et al. (2013) showed that future events are perceived as being closer to the present than objectively equidistant events in the past. Such asymmetry, which they termed the Temporal Doppler Effect, appears as early as the age of 4 (Burns et al., 2019). Caruso et al. (2013), following proposals by Clark (1973) and Lakoff & Johnson (1980), proposed that this asymmetry arises because the concrete experience of moving through space is used to conceptualize the more abstract domain of time. Thus, the experience of 'moving' through time inherits the experience of physical motion, such as the impression that objects that we approach are closer to us than objects we leave behind.

Other findings are also consistent with this view. Bluedorn (2002) observed a future-asymmetry using a temporal depth task: when he asked people to estimate in specific time units what a short-term, mid-term, and long-term future or past is for them, they looked farther into the future than into the past. Other studies have shown that future events are valued more than past events, both economically and emotionally (Buni, 2012; Burns et al., 2019; Caruso, 2010; Caruso et al., 2013; Caruso, Gilbert, & Wilson, 2008; Helzer & Gilovich, 2012; Kristal, O'Brien, & Caruso, 2019; Newby-Clark & Ross, 2003; Quoidbach, Gilbert, & Wilson, 2013; Ross & Newby-Clark, 1998; Van Boven & Ashworth, 2007), and Molouki, Hardisty, & Caruso (2019) found that as temporal distance to the present increased participants discounted past rewards more strongly than future ones. Finally, some studies have also shown that we tend to feel more continuity (similarity) with our future selves than with our past selves (Quoidbach, Gilbert, & Wilson, 2013; Rutt & Löckenhoff, 2016).

A different set of studies have suggested that the temporal asymmetry varies cross-culturally, depending on the culture's predominant temporal focus: the balance of attention and thinking that people devote to the future versus the past. Guo et al. (2012) showed that asking people to spend a few minutes thinking of things they did the past year versus the next year was enough to change the monetary valuation of a past versus a future event according to the priming. Attentional patterns can become habits and there is evidence that individuals differ in their predominant temporal focus. Future-focused people tend to be younger (de la Fuente et al., 2014), more conscientious (Li & Cao, 2017), liberal (Lammers & Baldwin, 2018; Li & Cao, 2020a), optimistic (Li & Cao, 2020b), organizational, proactive, efficient, open to change (Kruglanski, Pierro, & Higgins, 2015; Shipp & Aeon, 2019; Shipp, Edwards, & Lambert, 2009), and anxious (Eysenck, Payne, & Santos, 2006; Rinaldi et al., 2017)

than past-focused people. Culture can also modulate temporal focus (Callizo-Romero et al., 2020; de la Fuente et al., 2014; Li, VanBui, & Cao, 2018). The future asymmetries described in the previous paragraphs have all been found in Western samples, which are arguably more focused on the future than the past. East Asian cultures have been claimed to be past-focused (Guo et al., 2012; Ji et al., 2009; Kluckhohn & Strodtbeck, 1961). Consistently, a past asymmetry was found in Chinese participants: compared to Westerners, they gave a higher economic and emotional evaluation to past than future events (Guo et al., 2012; see also Guo & Spina, 2019).

The temporal motion hypothesis proposed by Caruso et al. (2013) can account for individual and cross-cultural differences in the degree of future temporal asymmetry but not for a full reversal (a past asymmetry), as this would seem to imply movement backwards in time. Guo et al. (2012) proposed a different explanation: The variations in temporal asymmetry in Westerners versus East Asians are caused by the balance of attention and thinking devoted to past versus future, that is, temporal focus (see also Callizo-Romero et al., 2020 and de la Fuente et al., 2014, for a similar proposal regarding time spatialization). Here, it is important for present purposes to emphasize that both accounts share a prediction: The magnitude of responses toward the future and toward the past must be negatively related. That is, the more we delve into the future, the less we delve into the past, and vice versa. This follows necessarily from the proposed underlying mechanisms. Motion toward the future implies motion away from the past. In the physical Doppler Effect, a single formula explains the rise in pitch as the object approaches the observer and its decrease as the object moves away (Doppler, 1842). The mechanisms of temporal focus can generate a temporal asymmetry between past and future in only one way: by devoting a greater amount of attention and thought (resources) to one than the other. As resources are considered to be limited, devoting more attention to the future should come with devoting less to the past.

All in all, what might be termed the dominant picture on this issue is that there is a basic future asymmetry that is strengthened in future-focused Western cultures but is reduced in past-focused East Asian cultures (specifically, Chinese) where it could become a past asymmetry. Two theoretical proposals have been put forward to explain this pattern: a temporal motion hypothesis and a temporal focus hypothesis. Both accounts agree that the observed asymmetries should be accompanied by a negative relation between the past and future. As the evidence supporting the dominant picture comes from very different temporal tasks, it is also an implicit methodological assumption in this field that temporal cognition manifests itself consistently in different measures of temporal thinking and valuation.

The dominant picture, however, has several limitations. First, some studies with Western participants did not support asymmetrical thinking with regards to temporal distance (Ji et al., 2019, study 1b), self-continuity (Guo & Spina, 2019; Molouki, Hardisty, & Caruso, 2019, studies 2a and 2b; and Rutt & Löckenhoff, 2016), and time discounting (Bickel et al., 2008; Molouki, Hardisty, & Caruso, 2019, study 2a; Pope et al., 2019; Stieg & Dixon, 2007; Yi, Gatchalian, & Bickel, 2006). Second, the predominance of the past focus in East Asian cultures has also been challenged (Gan et al., 2017; Gao, 2016; Ji et al., 2019; Wang et al., 2011). Third, some intercultural studies (Ji et al., 2019) found numeric past asymmetries in temporal distance for both Chinese and Western samples, although the relevant contrast between past and future was not carried out. Others such as Ji et al. (2009) only tested the past condition. Finally, there are three important methodological

limitations in the available research: (1) Cross-cultural differences in temporal focus have been assumed on a priori grounds, but temporal focus has not been explicitly measured; (2) to the best of our knowledge, the only (arguably) past-focused culture that has been explored is Chinese culture; and (3) no study has assessed several temporal tasks simultaneously in the same sample of participants, meaning we cannot be certain of the degree to which they render consistent results.

The present work aimed to overcome the methodological limitations in available research. We employed several different tasks used in the previous literature (adapting them when necessary) to assess temporal asymmetry: self-continuity, time discounting, temporal distance, and temporal depth, both toward the past and the future. We collected data from eight Western, Middle East, and East Asian cultural groups that were expected to differ in their temporal focus: Americans, Spaniards, Serbs, Croats, Bosniaks, Moroccans, Turks, and Chinese. Instead of assuming different degrees of temporal focus across our cultural samples, we measured this variable, and did so in two different ways: First, we measured the balance between past (tradition) and future (progress) temporal values by means of the Temporal Focus Questionnaire developed by de la Fuente et al. (2014). Second, we measured the balance between attention and thinking devoted to the personal past and future by means of the Temporal Focus Scale developed by Shipp, Edwards, & Lambert (2009).

With this methodological approach, the current work set out to answer four questions: (1) Is there asymmetry or symmetry toward past and future in each task? In other words, is the magnitude of responses toward the future stronger or weaker than the magnitude of responses toward the past? (2) Do past and future hold a negative or a positive relation in the mind? A negative relation means that individuals who produce responses of greater magnitude toward the future show a corresponding decrease in the magnitude of their responses toward the past (and vice versa). A positive relation between the past and the future occurs when the magnitude of responses toward the future and the past go hand in hand (note that this question is orthogonal to the presence or absence of asymmetry). (3) Do the putative asymmetries depend on temporal focus in such a way that people in more future-focused cultures show stronger future-asymmetries than those in past-focused cultures (who may even show past asymmetry)? Finally, (4) are the putative asymmetries in the different tasks correlated with each other? This would support the claim that the tasks measure a common psychological substrate.

2. Methods

All materials, data, and statistical analyses of the study reported in this article can be accessed at <https://osf.io/bwt5r/>.

2.1. Participants

Overall, 1,075 students took part in the study (702 female, 364 male, 1 other, and 8 nonresponses). All participants were university students, mostly in their early 20s (M age = 21.37 years, range = 15–63, with only 3.3% older than 30). University students may not accurately represent their country's overall population or testing site, but they provide samples of comparable age and education.

The data were collected in three waves. The Spanish sample ($N = 192$) was collected at the Faculty of Psychology, University of Granada, Spain, both in the first ($N = 96$) and second ($N = 96$) waves; the American sample ($N = 159$) was collected at McAnulty College and Graduate School of Liberal Arts, Duquesne University, Pittsburgh, Pennsylvania, USA, both in the first ($N = 64$) and second ($N = 96$) waves. The Moroccan group ($N = 142$) was tested in two cohorts in the second wave, separated by several months and in different locations. Many Moroccan participants from the first cohort gave signs of not being motivated and/or not understanding well the written items (e.g., left some subtasks without response, marked the same value in all items of a task, gave values for short-medium-long past or future which were not temporally ordered; or chose only one item in the entire time discounting task), which motivated the collection of a second cohort of participants. The first cohort of the Moroccan ($N = 96$) sample was tested at the Faculty of Arts, Abdelmalek Essaadi University, Tetouan, Morocco, and the second cohort ($N = 46$) at the Faculty of Law, University of Tanger, Morocco. The Turkish group ($N = 96$) was tested at Koç University, Istanbul, Turkey, in the second wave. In Bosnia–Herzegovina (total $N = 387$), the Serbian sample ($N = 188$) was collected at the University of Banja Luka both in the first ($N = 96$) and second ($N = 94$) waves, the Croatian sample was collected at the University of Mostar ($N = 100$) in the second wave, and the Bosniak sample was collected at the University of Tuzla ($N = 99$) in the second wave. Finally, the Chinese sample ($N = 96$) was collected at the Jiangsu Normal University, Xuzhou, China in the third wave.

The testing site was adopted as a proxy for each cultural group, such that in the analyses, all participants tested in each testing site were included in their respective cultural groups. We understand that this is not totally accurate, so we asked the participants about cultural identity in our questionnaires. However, it seems that the question was not understood correctly sometimes, and the answers were often unclear, so it was decided to include all the participants collected in a city within that cultural group. Nonetheless, this problem can not affect any of the within-participant contrasts. Moreover, as our between-group contrasts are based on explicitly measured temporal focus, and not on assumed temporal focus, we do not think that this problem threatens any of our conclusions. All participants signed the informed consent to participate. The study was approved by the Ethics Committees of the University of Granada (code 300/CEIH/2017), Duquesne University, and Koç University.

2.2. Materials

The tasks were translated from English into the language from each sample (Spanish, Chinese, Arabic, Turkish, and Serbian/Croatian/Bosnian) by bilingual researchers. We used the back-translation technique to confirm the equivalence of the translation between different language versions.

2.2.1. Self-continuity

To measure self-continuity, we used the Self-continuity Scale by Ersner-Hershfield et al. (2009), for which Rutt and Löckenhoff (2016) devised a past version. Participants were asked to think about themselves 10 years from now (future version) or 10 years ago (past version), and then they had to choose among seven pairs of circles

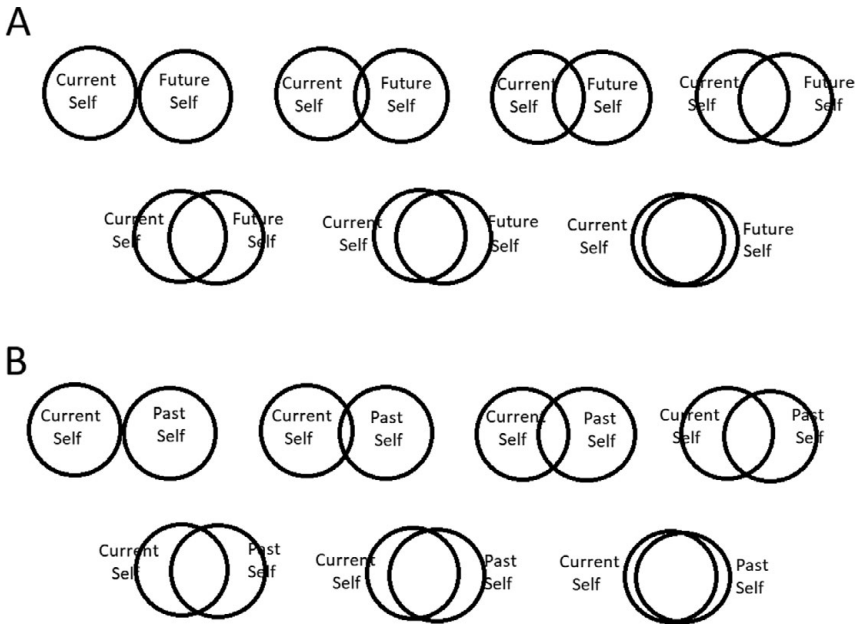


Fig. 1. Images used in the (A) future and (B) past version of the self-continuity scale.

labeled ‘current self’/‘future self’ (Fig. 1A) or ‘current self’/‘past self’ (Fig. 1B) that ranged from complete separation (1 = least similar) to almost complete overlap (7 = most similar).

2.2.2. Time discounting

We used the Time Discounting Scale developed by Kirby and Maraković (1996), which is a classic measure widely used to study temporal discounting (Frederick, Loewenstein, & O’Donoghue, 2002). It consists of 21 items offering a choice between an immediate but smaller, and a delayed but larger amount. Thus, the participant had to choose between, for example, ‘\$45 tonight or \$70 in 35 days’. The original task only measured time discounting toward the future. In the present study, we created a past version using the same amounts and delays, for example, participants chose between \$45 last night or \$70, 35 days ago. We computed the frequency of choosing the distant option in each version. The temporal intervals ranged from 10 to 75 days. In the American version, the amounts offered ranged from \$16 to \$85. Amounts in the scale were translated into the different currencies of the countries involved in this study applying conversion rates based on Purchasing Power Parity, such that they would be roughly equivalent for the participants.

Intuitively, a reward already given in the past may seem very different than a reward to be given in the future. However, both temporal distances involve trade-offs that may affect the value a person assigns to the reward: A larger reward in the distant past may be less attractive than a smaller reward received recently because the former may have already been spent at the present moment. A larger reward in the distant future (vs. a shorter reward immediately) forces the participant to wait before getting it. Previous studies show abundant evidence that people discount past rewards.

And tasks comparing past and future time discounting have been used to address the question of temporal asymmetry before (see Supplementary Table S1).

2.2.3. Temporal distance

We used the Temporal Distance Task from Caruso et al. (2013); study (1a). This task has both a future and a past version. Participants were asked either to think ahead to exactly 1 month from today (future version) or to think back to exactly one month ago (past version) and were asked how long this time interval feels. Participants had to respond on a Likert scale from 1 (*a really short time from now*) to 5 (*a really long time from now*). The only difference between the task by Caruso et al. (2013) and ours is that they used a 10-point response scale, and we used a 5-point response scale.

2.2.4. Temporal depth

We measured temporal depth with a slight adaptation of the task developed by Bluedorn (2002). This task presents three questions referring to different temporal depths (short-term, mid-term, and long-term) concerning both the past and the future. In our adaptation, questions about the future and the past were phrased using the same terms. The short-term future version used the following sentence: ‘When I think of the short-term future, I usually think of events that will occur _____ from now’; and for the past version: ‘When I think of the short-term past, I think of events that occurred _____ ago’. The expression ‘short-term’ was replaced by ‘midterm’ and ‘long-term’ in the midterm and the long-term version respectively. In Bluedorn’s (2002) task, participants chose from a fixed set of 15 response options showing increasingly longer temporal distance (being, e.g., 1 = *one day*, 2 = *one week*, [...] 14 = *25 years*, and 15 = *more than 25 years*). Instead, we gave participants complete freedom to choose any temporal amount, but participants were instructed to respond with a specific moment, not a temporal range. When they still gave a range (e.g., ‘2 or 3 months’), we took the midpoint.

2.2.5. Temporal focus

We used two measures of temporal focus.

Temporal focus questionnaire. The first measure of temporal focus was de la Fuente et al.’s (2014) Temporal Focus Questionnaire, with a slight adaptation (one item was removed). This questionnaire measures the value given to past (tradition) versus future (progress). It contained 20 items: 10 referred to past-related values (e.g., ‘The traditional way of living is better than the modern way’) and 10 referred to future-related values (e.g., ‘It is important to innovate and to adapt to changes’). Each item was followed by a Likert scale from 1 (*total disagreement*) to 5 (*total agreement*). The items were presented in random order in the first wave, but in the second wave, they were presented in strict alternating order, as in de la Fuente et al. (2014). In the third wave, we used the same order as in the second wave, except for two items which exchanged places due to experimenter error. In addition, the American version of the questionnaire in the first wave and the Turkish version in the second wave used 9-point scales, so the responses to these versions were converted to the range 1–5. The McDonald’s Omega coefficients (ω) for the past and future items in the Temporal Focus Questionnaire were, respectively: $\omega = 0.84$ and $\omega = 0.69$ in Spaniards; $\omega = 0.86$

and $\omega = 0.65$ in Americans; $\omega = 0.86$ and $\omega = 0.78$ in Serbs; $\omega = 0.90$ and $\omega = 0.79$ in Croats; $\omega = 0.87$ and $\omega = 0.71$ in Bosniaks; $\omega = 0.84$ and $\alpha = 0.67$ in Moroccans; $\omega = 0.87$ and $\omega = 0.81$ in Turks; and $\omega = 0.67$ and $\omega = 0.73$ in Chinese.

Temporal focus scale. The second measure of temporal focus was Shipp, Edwards, & Lambert's (2009) Temporal Focus Scale. This instrument measures the amount of attention and thinking devoted to the personal past, present, and future. It contains 12 items, three devoted to the past (e.g., 'I think about things from my past'), three to the present (e.g., 'My mind is on the here and now'), and three to the future (e.g., 'I think about times to come'). Each item was followed by a Likert scale from 1 (*never*) to 5 (*constantly*). The items from the three subscales were presented to the participants, but the present subscale was not analyzed because it is irrelevant to the question of temporal asymmetry. The McDonald's Omega coefficients (ω) for the past and future items in the Temporal Focus Scale were, respectively: $\omega = 0.83$ and $\omega = 0.81$ in Spaniards; $\omega = 0.84$ and $\omega = 0.72$ in Americans; $\omega = 0.91$ and $\omega = 0.71$ in Serbs; $\omega = 0.90$ and $\omega = 0.76$ in Croats; $\omega = 0.90$ and $\omega = 0.88$ in Bosniaks; $\omega = 0.80$ and $\omega = 0.75$ in Moroccans; $\omega = 0.92$ and $\omega = 0.84$ in Turks; and $\omega = 0.83$ and $\omega = 0.73$ in Chinese.

2.3. Procedure

The present study is part of a wider project aimed to assess time conceptualization across a wide range of cultures using a variety of tasks, some of which form the basis of the current article. The sample of the present work has recently been used in another published article (Callizo-Romero et al., 2020) in which we investigated how temporal focus affects temporal spatialization. In the present work, we focus on the question of whether people conceptualize the past and the future symmetrically or asymmetrically.

Data were collected in three different waves. In the first wave, data was collected from Spanish, American, and Serbian participants using only the Temporal Depth Task and the Temporal Focus Questionnaire, as well as other tasks not reported in this article. In the second wave, the Self-Continuity Scale, the Time Discounting Scale, and the Temporal Distance Task, as well as a new measure of temporal focus, the Temporal Focus Scale, were added along with other tasks. We collected new samples of previous cultural groups (Spaniards, Americans, and Serbs), as well as Bosniaks, Croats, Moroccans, and Turks. In the third wave, a sample of Chinese participants was collected who performed the same tasks as the samples collected in Wave 2. No participant performed the tasks more than once. In our analyses, we used the data from the three waves pooled together. The minimum sample size of each cultural group in each wave was established at 96 before the beginning of data collection. This number resulted from doubling the minimum number (48) necessary for a full run of the counterbalancing of all the tasks that the participants would perform during the session (which included the tasks not described here, some of which had several versions).

The tasks were completed in corresponding universities' facilities for each sample, using pen and paper. Participants received a leaflet with the battery of tasks. The leaflet started with the instructions and the consent form. Next, the participants filled in a demographic questionnaire. After that, temporal tasks appeared in this

order: Self Continuity Scale, Time Discounting Scale, Temporal Distance Task, and Temporal Depth Task (except for Wave 1 of data collection, where the first three tasks were not used). Participants performed both versions (past and future) of the tasks in a counterbalanced order, such that half the participants started with the past versions of all the tasks followed by the future versions in the same order, while the other half started with the future versions followed by the past versions. The penultimate task of this series was always the Temporal Focus Scale, and the final task was the Temporal Focus Questionnaire (with the exception of Wave 1, when the former was not used). At the bottom of each page, the instructions emphasized that participants should not turn the page until the exercise on that page had been completed nor to look ahead or back to other pages.

2.4. Data processing and analysis

We preprocessed the data to eliminate invalid responses. First, we filtered out data that fulfilled certain criteria indicating poor attention or faulty understanding of the tasks' instructions. The first criterium was applied to all multi-item tasks (temporal discounting and the two tasks measuring temporal focus). We removed participants who did not show any variability in their responses over items or left more than four items blank. For this reason, in the Time Discounting Scale, 79 participants were filtered out (most from the first Moroccan cohort, which led to the collection of the second Moroccan cohort), leaving a total sample in that task of $N = 740$. In the Temporal Focus Scale, one participant was filtered out (total $N = 814$). In the Temporal Focus Questionnaire, six participants were filtered out (total $N = 1,069$). A second criterium was applied to the Temporal Depth Task, where we filtered out 195 participants because they either did not respect the temporal progression of short, medium, and long terms (i.e., gave a shorter time for a longer-term horizon) or, more often, gave a too vague estimation in at least one item (e.g., they wrote 'weeks' or 'years'). The final sample size in this task was $N = 880$. In the Self-Continuity Scale ($N = 815$) and the Temporal Distance Task ($N = 816$), no participant was removed.

Statistical analyses were tailored to answer our four questions: the asymmetry question, the question about the sign of the relation between past and future (positive or negative), the temporal focus question, and the question of whether the tasks measure a single underlying temporal dimension. The analyses were conducted for each task both on the overall sample and within each cultural group.

To answer the asymmetry question, we took both between-groups and within-participant approaches in order to rule out the possibility of strategic effects when the same participant was asked about both the past and the future (see Caruso, Gilbert, & Wilson, 2008). All participants responded to both the past and future versions of each task. Due to counterbalance, half of the participants responded first to the past versions of all tasks while the other half responded first to the future versions of all tasks. This allowed us to perform both a within-participant analysis, using all responses, as well as a between-groups analysis using only the responses to the version of the tasks that were responded to in first place. Thus, for the between-groups analyses, we compared the responses to the past versions of the task in one-half of the participants to the responses to the future versions of the task in the other half.

For the within-participant analyses, we computed an asymmetry index for each participant in each task. In order to secure a common interpretation for all the tasks' indexes, we inverted the response values in the Temporal Distance Task's scale (i.e., we computed 1 as 'a really long time from now' and 5 as 'a really short time from now'). In this way, greater values in this task indicate a smaller distance to the event. In the Self-Continuity Scale, greater values also indicate a greater self-continuity to a distant self (see Fig. 1). In the Time Discounting Task, we counted the number of distant choices, which indicates less discounting (i.e., greater value of distant rewards). Finally, in the Temporal Depth Task, we converted all responses to days and computed four indexes: short, medium, and long-term indexes as well as a general index using the standard deviation of the scores in the three temporal depths (short, medium, and long). Greater values indicate a longer temporal horizon, which is consistent with a closer perceived distance (and greater value) of more distant events.

Computing asymmetry indexes eases cross-measures comparisons by putting all of them on a common scale. For the interested reader, the median and interquartile ranges of each past and future condition in each culture are reported in the Supplementary Tables S2–S4. The creation of the asymmetry indexes in all measures followed the strategy used by de la Fuente et al. (2014): $\text{Index} = [\text{mean of future version responses} - \text{mean of past version responses}] / [\text{mean of future version responses} + \text{mean of past version responses}]$. The indexes expressed the asymmetry between the responses in the past and future versions on a scale from -1 to $+1$. An index significantly greater than zero means a future asymmetry. That is, a positive index indicates, as compared to the past, greater continuity with the future self, perception of smaller distance to the future event, greater patience for future economic rewards, greater temporal depth into the future, and a future temporal focus. An index significantly smaller than zero means a past asymmetry.

In order to assess whether the relation between past and future processing is positive or negative, we computed correlations between the responses to the past and future versions of each task over participants, both within cultural groups and over the whole sample.

To answer the temporal focus question, we averaged responses to the items in the past and the future subscales of both the Temporal Focus Questionnaire and the Temporal Focus Scale. Then, we computed asymmetry indexes for each measure, following the same approach described above. For simplicity, we will call the index that comes from the Temporal Focus Questionnaire 'value temporal focus': it represents the balance between the importance given to past (tradition) and future (progress) temporal values, and we will call the index that comes from the Temporal Focus Scale 'personal temporal focus': it represents the balance between the attention and thinking devoted to the personal past versus future.

We then took both a group-level and an individual-level approach. For the group-level approach, we ranked cultures from future-focused to past-focused in each of the temporal focus indexes, and assessed whether the size of the asymmetries observed in the other temporal tasks agreed with this ranking. Moreover, we also pooled together all cultures that showed qualitatively different kinds of temporal focus in each index and contrasted them in the temporal tasks. At the individual-level approach, we computed correlations between each temporal focus index and the asymmetry indexes of the temporal tasks.

Finally, in order to answer the question about the existence of an underlying temporal dimension, we correlated the asymmetry indexes of each task with each other and we also performed an exploratory factor analysis (using the minimum residual extraction method).

Since all samples have more than 50 participants, deviations from normality were checked with the Lilliefors test (based on the Kolmogorov–Smirnov test) showing that the asymmetry indexes for the overall sample in all the tasks did not follow a normal distribution (in all cases $p < 0.01$). Analyses for each task within each culture, both regarding the asymmetry indexes as well as in the past and future versions taken independently showed that normality was violated in most cases (the supplementary data and analysis scripts allow the replication of these tests). For this reason, we turned to nonparametric analyses. We report the uncorrected p values, but we carried out corrections for false discovery rate (FDR) over the set of relevant comparisons following Benjamini & Hochberg (1995), and also report what contrasts did survive the correction. We based our conclusions only on those tests that remained significant after FDR correction.

3. Results

3.1. Is there asymmetry in temporal cognition?

3.1.1. Between-groups analysis of temporal asymmetry

When comparing within each culture the group that responded to the past versions of the tasks in the first half of the task battery with the group that responded to the future versions, Mann–Whitney tests revealed a significant future asymmetry in self-continuity in Spaniards ($U = 748.5$, $p < 0.01$, $r_{rb} = 0.21$, 95% CI [0.07, 0.34]), Americans ($U = 812$, $p = 0.01$, $r_{rb} = 0.2$, 95% CI [0.05, 0.35]), Serbs ($U = 817$, $p = 0.04$, $r_{rb} = 0.15$, 95% CI [0.01, 0.28]), Croats ($U = 963$, $p = 0.04$, $r_{rb} = 0.2$, 95% CI [0.02, 0.39]), and Turks ($U = 605$, $p < 0.001$, $r_{rb} = 0.4$, 95% CI [0.24, 0.58]), but not in Bosniaks ($U = 1,082$, $p = 0.32$, $r_{rb} = 0.1$, 95% CI [−0.12, 0.030]), Moroccans ($U = 2,351$, $p = 0.48$, $r_{rb} = 0.06$, 95% CI [−0.12, 0.23]), and Chinese ($U = 1,139$, $p = 0.92$, $r_{rb} = 0.01$, 95% CI [−0.2, 0.21]). After FDR correction, the comparisons in Americans, Serbs, and Croats became insignificant. In the rest of the tasks the only significant asymmetries were a future asymmetry in time discounting in both the Spaniards ($U = 818$, $p = 0.01$, $r_{rb} = 0.18$, 95% CI [0.04, 0.31]) and the Chinese ($U = 595$, $p < 0.001$, $r_{rb} = 0.42$, 95% CI [0.25, 0.58]), and in temporal depth in Chinese both in the general measure ($U = 746$, $p < 0.01$, $r_{rb} = 0.28$, 95% CI [0.09, 0.48]) and in the long term ($U = 757$, $p < 0.01$, $r_{rb} = 0.27$, 95% CI [0.07, 0.47]). All these contrasts remained significant after FDR correction. Summing up, we found significant future asymmetry in self-continuity in Spaniards and Turks; in time discounting in Spaniards and Chinese; and in temporal depth in Chinese, both in the general measure and in the long term. No other culture in any task showed significant asymmetry.

Pooling together all participants in each task, we found an overall future asymmetry in self-continuity ($U = 66,157$, $p < 0.001$, $r_{rb} = 0.16$, 95% CI [0.1, 0.22]) and in time discounting ($U = 75,006$, $p < 0.01$, $r_{rb} = 0.08$, 95% CI [0.016, 0.14]), both of which remained significant after FDR correction. No temporal asymmetry was found in temporal distance and temporal depth, neither in the general measure nor in the short, medium, or long terms (in all cases $p > 0.3$).

Table 1. Sample size of asymmetry indexes in each task and each culture

Country culture	Spaniards	Chinese	Turks	Americans	Moroccans	Bosniaks	Croats	Serbs
Self-continuity index	95	96	96	96	141	98	100	93
T. discounting index	95	93	96	96	83	94	96	87
T. distance index	96	96	96	96	142	99	100	94
T. depth short index	144	94	88	121	99	82	89	162
T. depth mid index	144	94	88	121	100	82	89	162
T. depth long index	144	94	88	121	100	82	89	162
T. depth <i>SD</i> index	144	94	88	121	100	82	89	162
T. focus index (TFQ)	192	96	96	159	139	99	100	188
T. focus index (TFS)	96	96	96	96	137	99	100	94

3.1.2. Within-participant analysis of temporal asymmetry

We used the responses of all participants to both the past and future versions of the tasks to compute asymmetry indexes as detailed above. The overall results and most of the culture-wise results revealed a similar pattern of findings to the between-group analysis as well as an additional asymmetry in the Temporal Depth Task (Table 1 shows sample sizes in each index and culture, Fig. 2 shows the results, and Fig. 3 breaks down the Temporal Depth Task into the three asymmetry indexes). Wilcoxon rank tests showed that the self-continuity index was significantly greater than zero in Spaniards ($W = 2,962, p < 0.001, r_{tb} = 0.4, 95\% \text{ CI } [0.3, 0.51]$), Americans ($W = 2,434, p < 0.001, r_{tb} = 0.31, 95\% \text{ CI } [0.18, 0.44]$), Serbs ($W = 1,654, p < 0.001, r_{tb} = 0.25, 95\% \text{ CI } [0.13, 0.38]$), Bosniaks ($W = 1,802, p < 0.001, r_{tb} = 0.42, 95\% \text{ CI } [0.26, 0.58]$), Croats ($W = 2,220, p < 0.001, r_{tb} = 0.57, 95\% \text{ CI } [0.45, 0.69]$), and Turks ($W = 2,150, p < 0.001, r_{tb} = 0.42, 95\% \text{ CI } [0.24, 0.59]$), but not in Chinese ($W = 1,667, p = 0.13, r_{tb} = 0.15, 95\% \text{ CI } [-0.04, 0.35]$) and Moroccans ($W = 2,232, p = 0.72, r_{tb} = 0.03, 95\% \text{ CI } [-0.14, 0.19]$). FDR correction did not change these findings. Time discounting showed a future asymmetry in Spaniards ($W = 2,196, p = 0.04, r_{tb} = 0.15, 95\% \text{ CI } [0.019, 0.29]$), which became insignificant after FDR correction, and Chinese ($W = 2,491, p < 0.001, r_{tb} = 0.51, 95\% \text{ CI } [0.37, 0.66]$), which remained after FDR correction. There was also asymmetry in the general temporal depth index in Chinese ($W = 2,502, p < 0.001, r_{tb} = 0.43, 95\% \text{ CI } [0.26, 0.60]$) which also remained after FDR correction. Regarding each of the temporal depths, we only found asymmetry in the Turks in the mid-term ($W = 1,629, p = 0.02, r_{tb} = 0.23, 95\% \text{ CI } [0.03, 0.42]$) and in the Chinese in all depths: short-term ($W = 1,285, p = 0.03, r_{tb} = 0.22, 95\% \text{ CI } [0.04, 0.42]$), mid-term ($W = 1,305, p = 0.04, r_{tb} = 0.21, 95\% \text{ CI } [0.02, 0.40]$), and long-term ($W = 1,828, p < 0.001, r_{tb} = 0.41, 95\% \text{ CI } [0.25, 0.58]$). However, after FDR correction, only the asymmetry in the long-term temporal depth in the Chinese remained. Summing up, all cultures except Moroccans and Chinese showed future asymmetry in self-continuity, and only the Chinese showed future asymmetry in time discounting and both general and long-term temporal depth. No other culture in any task showed asymmetry.

We analyzed the overall asymmetry in each task by pooling all participants together (see Fig. 4). We found a significant future asymmetry in the self-continuity index ($W = 134,341, p < 0.001, r_{tb} = 0.30, 95\% \text{ CI } [0.25, 0.35]$), the time discounting index ($W = 93,772, p < 0.001, r_{tb} = 0.11, 95\% \text{ CI } [0.05, 0.17]$), and the temporal depth index ($W = 144,476, p = 0.001, r_{tb} = 0.10, 95\% \text{ CI } [0.04, 0.16]$), but we did not find an overall asymmetry in the temporal distance index ($W = 53,689, p = 0.38,$

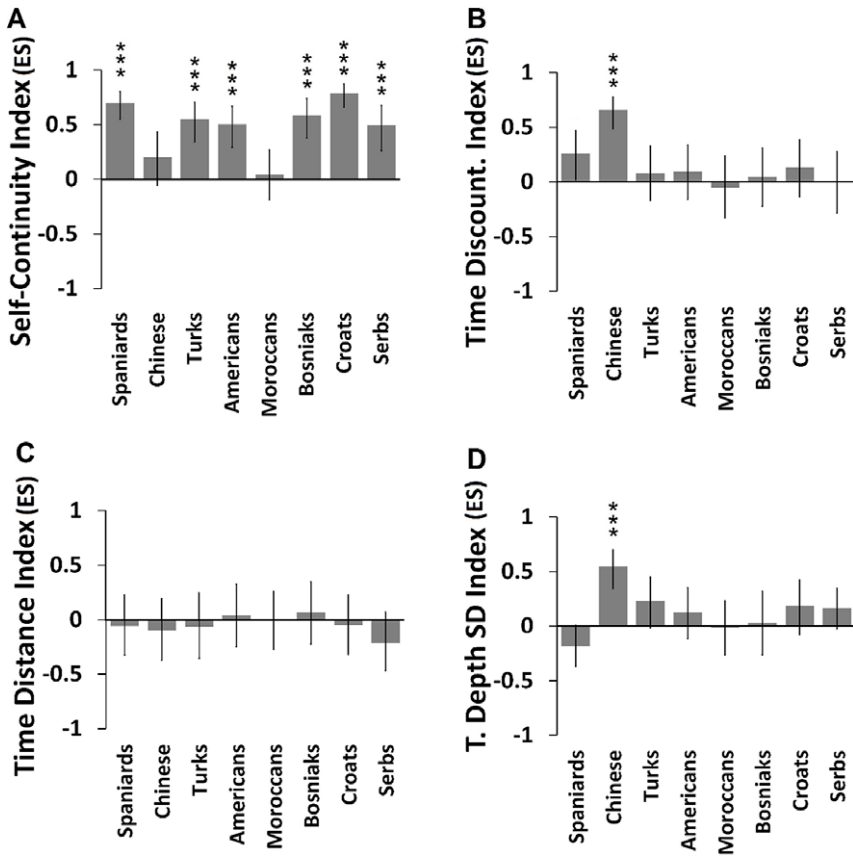


Fig. 2. Bar graphs representing the effect size of asymmetry indexes computed for each task in each culture ordered from the most future-focused to the most past-focused culture according to the temporal focus questionnaire index: (A) self-continuity scale; (B) time discounting scale; (C) temporal distance task; and (D) temporal depth task. Effect sizes are calculated by rank-biserial correlation. Error bars indicate 95% confidence interval of the effect size. Statistically significant results after false discovery rate correction for multiple comparisons are marked with asterisks: *** $p < 0.001$.

$r_{tb} = -0.03$, 95% CI [-0.09, 0.04]). In temporal depth, the asymmetry was only present in the long-term ($W = 87,621$, $p = 0.01$, $r_{tb} = 0.08$, 95% CI [0.02, 0.14]), but not in the mid or short terms (in both cases, $p > 0.36$). All the significant tests remained significant after FDR correction.

3.2. Do past and future hold a positive or a negative relationship in the mind?

Kendall's Tau B correlation coefficient (FDR corrected) showed that the past and future versions were significantly and positively correlated in all tasks and cultures (in all cases $p < 0.01$), with the only exceptions of Serbs in the Self-continuity Scale and Americans in Self-continuity Scale and Time Distance Task (see Table 2 and Fig. 5).

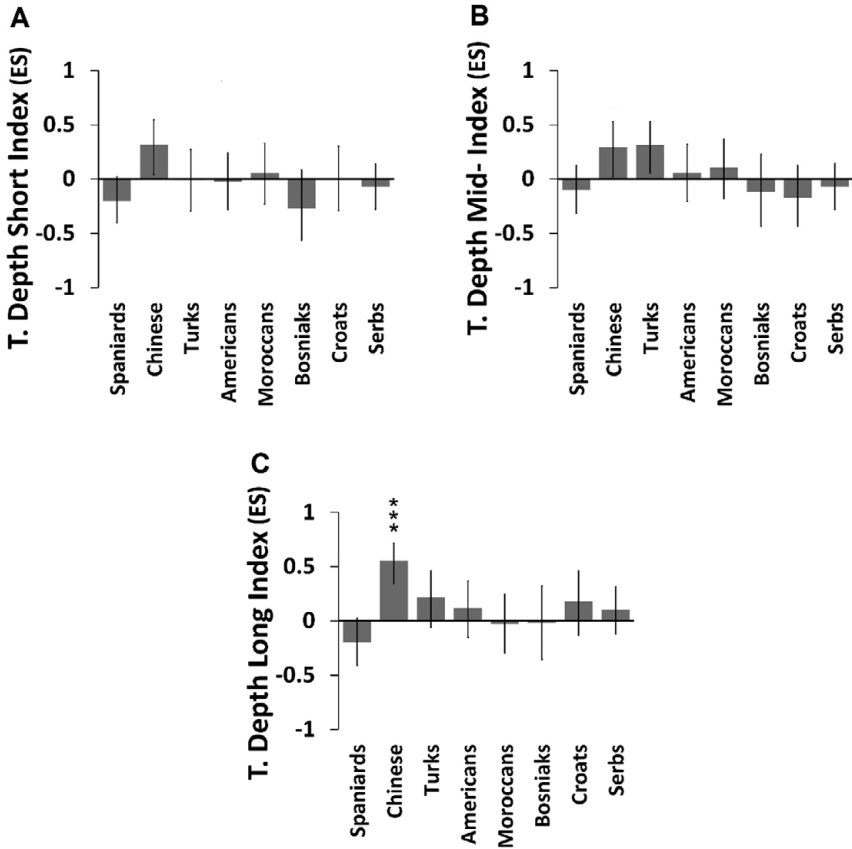


Fig. 3. Bar graphs representing the effect size of temporal depth indexes computed for each culture ordered from the most future-focused to the most past-focused culture according to the temporal focus questionnaire index: (A) short-term; (B) midterm; and (C) long-term. Effect sizes are calculated by rank-biserial correlation. The error bars show the 95% confidence interval of the effect size. Statistically significant results after false discovery rate correction for multiple comparisons are marked with asterisks: *** $p < 0.001$.

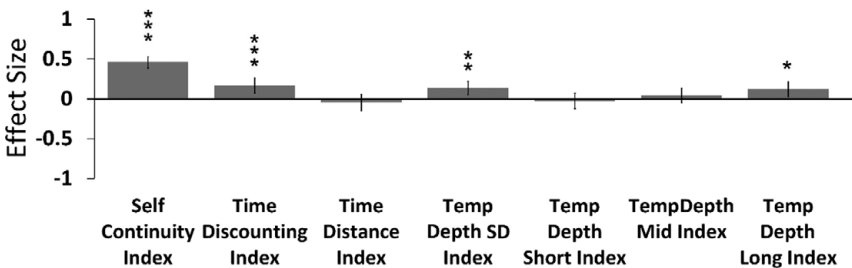


Fig. 4. Bar graph representing the effect size of the difference of temporal asymmetry indexes with zero computed for each task in the overall sample. Effect sizes are calculated by rank-biserial correlation. The error bars show the 95% confidence interval of the effect size. Statistically significant results after false discovery rate correction for multiple comparisons are marked with asterisks: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 2. Kendall's tau correlations between the past and the future versions in each task and culture

	Self-continuity	Time discounting	Temporal distance	Temporal depth	T. Depth short-term	T. Depth mid-term	T. Depth long-term
Spaniards	$\tau_b = 0.31^{***}$ $N = 95$	$\tau_b = 0.6^{***}$ $N = 95$	$\tau_b = 0.22^{**}$ $N = 96$	$\tau_b = 0.61^{***}$ $N = 144$	$\tau_b = 0.51^{***}$ $N = 163$	$\tau_b = 0.58^{***}$ $N = 165$	$\tau_b = 0.67^{***}$ $N = 156$
Chinese	$\tau_b = 0.26^{***}$ $N = 96$	$\tau_b = 0.48^{***}$ $N = 93$	$\tau_b = 0.25^{**}$ $N = 96$	$\tau_b = 0.34^{***}$ $N = 94$	$\tau_b = 0.41^{***}$ $N = 94$	$\tau_b = 0.45^{***}$ $N = 94$	$\tau_b = 0.43^{***}$ $N = 94$
Turks	$\tau_b = 0.24^{**}$ $N = 96$	$\tau_b = 0.40^{***}$ $N = 96$	$\tau_b = 0.24^{**}$ $N = 96$	$\tau_b = 0.39^{***}$ $N = 88$	$\tau_b = 0.52^{***}$ $N = 91$	$\tau_b = 0.55^{***}$ $N = 91$	$\tau_b = 0.43^{***}$ $N = 91$
Americans	$\tau_b = 0.08$ $N = 96$	$\tau_b = 0.48^{***}$ $N = 96$	$\tau_b = 0.15$ $N = 96$	$\tau_b = 0.55^{***}$ $N = 121$	$\tau_b = 0.57^{***}$ $N = 129$	$\tau_b = 0.65^{***}$ $N = 125$	$\tau_b = 0.61^{***}$ $N = 123$
Moroccans	$\tau_b = 0.22^{***}$ $N = 141$	$\tau_b = 0.50^{***}$ $N = 83$	$\tau_b = 0.37^{***}$ $N = 140$	$\tau_b = 0.53^{***}$ $N = 100$	$\tau_b = 0.49^{***}$ $N = 90$	$\tau_b = 0.57^{***}$ $N = 100$	$\tau_b = 0.57^{***}$ $N = 100$
Bosniaks	$\tau_b = 0.28^{***}$ $N = 98$	$\tau_b = 0.62^{***}$ $N = 94$	$\tau_b = 0.31^{***}$ $N = 99$	$\tau_b = 0.66^{***}$ $N = 82$	$\tau_b = 0.64^{***}$ $N = 93$	$\tau_b = 0.672^{***}$ $N = 88$	$\tau_b = 0.78^{***}$ $N = 86$
Croats	$\tau_b = 0.37^{***}$ $N = 100$	$\tau_b = 0.5^{***}$ $N = 96$	$\tau_b = 0.26^{**}$ $N = 100$	$\tau_b = 0.53^{***}$ $N = 89$	$\tau_b = 0.64^{***}$ $N = 93$	$\tau_b = 0.74^{***}$ $N = 92$	$\tau_b = 0.68^{***}$ $N = 93$
Serbs	$\tau_b = 0.14$ $N = 93$	$\tau_b = 0.52^{***}$ $N = 87$	$\tau_b = 0.30^{***}$ $N = 93$	$\tau_b = 0.62^{***}$ $N = 162$	$\tau_b = 0.58^{***}$ $N = 167$	$\tau_b = 0.64^{***}$ $N = 173$	$\tau_b = 0.70^{***}$ $N = 170$
Overall	$\tau_b = 0.24^{***}$ $N = 815$	$\tau_b = 0.52^{***}$ $N = 740$	$\tau_b = 0.29^{***}$ $N = 816$	$\tau_b = 0.56^{***}$ $N = 880$	$\tau_b = 0.57^{***}$ $N = 927$	$\tau_b = 0.62^{***}$ $N = 928$	$\tau_b = 0.62^{***}$ $N = 913$

Note. Statistically significant results after false discovery rate correction for multiple comparisons are marked with asterisks: $**p < 0.01$, $***p < 0.001$.

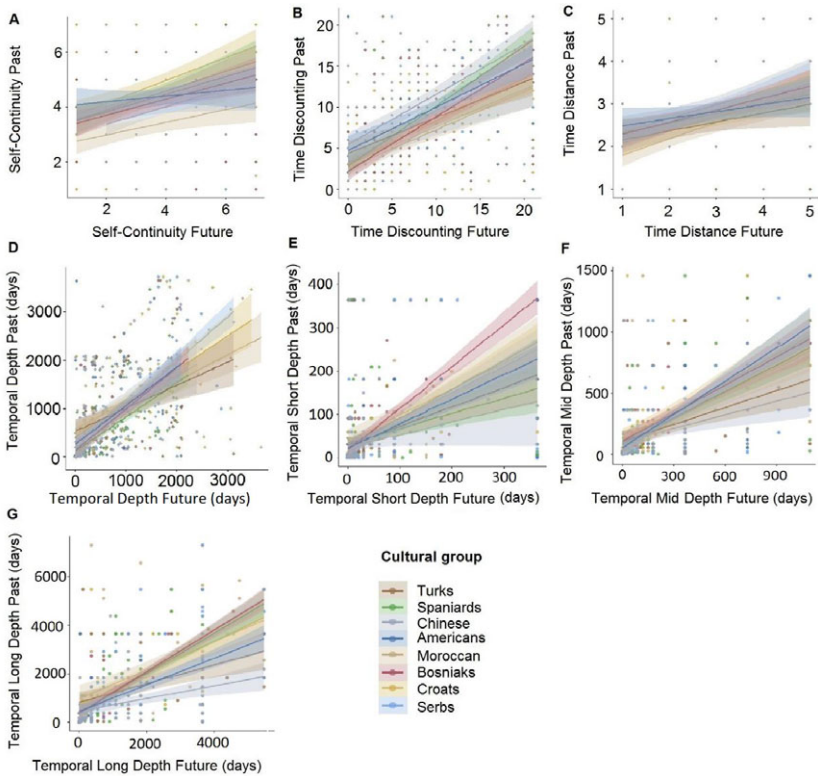


Fig. 5. Scatter-plots showing the correlations between responses in the past and future versions of each task: self-continuity scale (A); time discounting scale (B); temporal distance task (C); temporal depth task (D); temporal depth task short-term (E); temporal depth task mid-term (F); and temporal depth task long-term (G). The regression line and the standard error are shown for each culture.

3.3. Does temporal focus affect the asymmetry of the temporal tasks?

3.3.1. Temporal focus regarding past (tradition) versus future (progress) values

Using the temporal focus index from the Temporal Focus Questionnaire (value temporal focus index), we compared the index in each culture with zero to assess whether the cultures have an asymmetric temporal focus regarding the importance they give to tradition versus progress. According to Wilcoxon rank tests, the value temporal focus index was significantly different from zero in almost all cultural groups (see Fig. 6): we found a future focus in Spaniards ($W = 14,456$, $p < 0.001$, $r_{rb} = 0.64$, 95% CI [0.56, 0.72]), Chinese ($W = 3,137$, $p < 0.001$, $r_{rb} = 0.53$, 95% CI [0.39, 0.68]), and Turks ($W = 3,481$, $p < 0.001$, $r_{rb} = 0.51$, 95% CI [0.36, 0.66]); and a past focus in Moroccans ($W = 3,514$, $p = 0.03$, $r_{rb} = -0.19$, 95% CI [-0.35, -0.02]), Bosniaks, ($W = 1,505$, $p = 0.02$, $r_{rb} = -0.23$, 95% CI [-0.42, -0.04]), Croats ($W = 1,585$, $p = 0.01$, $r_{rb} = -0.26$, 95% CI [-0.44, -0.08]), and Serbs ($W = 3,375$, $p < 0.001$, $r_{rb} = -0.49$, 95% CI [-0.60, -0.37]). Only the Americans did not show a value temporal focus asymmetry ($W = 6,388$, $p = 0.29$, $r_{rb} = 0.08$, 95% CI [-0.07, 0.24]).

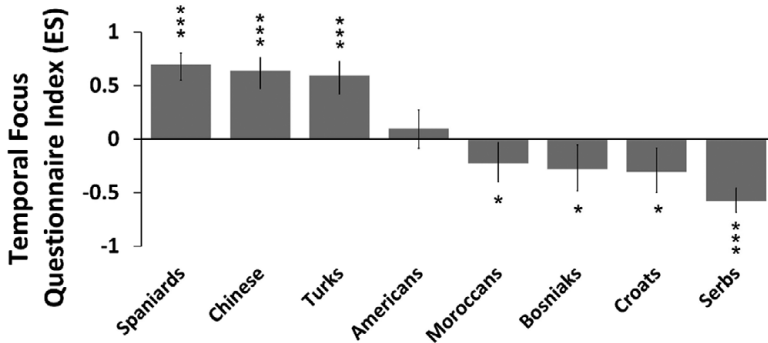


Fig. 6. Bar graph representing the effect size of the difference between the asymmetry index of the temporal focus questionnaire with zero in each culture. Effect sizes are calculated by rank-biserial correlation. The error bars show the 95% Confidence Interval of the effect size. Statistically significant results are marked with asterisks: * $p < 0.05$ and *** $p < 0.001$.

Figs. 2 and 3 show the asymmetry indexes in each task and each cultural group. In them, cultures appear ordered according to their value temporal focus index, as shown in Fig. 6: from the more future-focused (on the left) to the more past-focused (on the right). As it is immediately obvious, the degree of temporal asymmetry over cultures did not follow the pattern shown in this temporal focus index in any task. The only finding consistent with expectations is that in time discounting and temporal depth the only culture with a significant future asymmetry (Chinese) is among the three that have a future temporal focus. The size of Kendall's Tau Correlations at the group level (in all cases, $N = 8$) supported these impressions, although none reached significance (Self-continuity: $\tau_b = 0$, $p = 1$; Time Discounting: $\tau_b = 0.52$, $p = 0.08$; Time Distance: $\tau_b = 0$, $p = 1$; Temporal Depth SD: $\tau_b = 0.04$, $p = 0.9$; Temporal Depth Short: $\tau_b = 0.15$, $p = 0.61$; Temporal Depth Mid: $\tau_b = 0.44$, $p = 0.13$; Temporal Depth Long: $\tau_b = 0.15$, $p = 0.62$). To provide a strongest test (with higher statistical power), we also pooled together all participants from cultures with a significant future temporal focus (Spaniards, Chinese, and Turks) and compared their asymmetry indexes in the different tasks with participants from cultures with a past temporal focus (Moroccans, Bosniaks, Croats, and Serbs). The contrast in value temporal focus between the future-focused cultures ($N = 384$) and the past-focused cultures ($N = 526$) was strong and significant ($U = 479,007$, $p < 0.001$, $r_{tb} = 0.53$, 95% CI [0.47, 0.58]). However, future-focused cultures and past-focused cultures only differed significantly in time discounting (future group $N = 284$; past group $N = 360$; $U = 44,524$, $p < 0.01$, $r_{tb} = 0.13$, 95% CI [0.04, 0.22]) and in mid-term temporal depth (future group $N = 326$; past group $N = 433$, $U = 76,549.5$, $p = 0.04$, $r_{tb} = 0.085$, 95% CI [0.00, 0.17]), but only the results in time discounting remained statistically significant after the FDR correction. The difference went in the expected direction: people from future-oriented cultures showed a stronger future asymmetry than past-oriented cultures, which showed symmetry. No other temporal task revealed an effect of this index of temporal focus.

Finally, we tested whether value temporal focus correlated with temporal asymmetries in each task at the individual level, both within each culture as well as over the whole sample of participants. We computed Kendall's Tau B correlation coefficients (with FDR correction) between the value temporal focus index and the asymmetry

indexes using only those participants with valid data in the relevant task. The results indicated that temporal focus correlated with time distance in the overall sample ($\tau_b = -0.06, p = 0.02, N = 815$), and with time discounting in Moroccans ($\tau_b = 0.19, p = 0.02, N = 82$), but these correlations did not survive FDR correction; and with time discounting in both the overall sample ($\tau_b = 0.08, p < 0.001, N = 738$), and in Serbs ($\tau_b = 0.22, p = 0.004, N = 86$), both of which remained after FDR correction.

3.3.2. Temporal focus regarding the attention and thinking devoted to the personal past versus future

Using the temporal focus index from the Temporal Focus Scale (personal temporal focus index), we again compared the index in each culture with zero to assess whether the cultures have an asymmetrical temporal focus regarding the amount of attention and thinking they devote to the personal past and future (Fig. 7). According to Wilcoxon rank tests, the personal temporal focus index was significantly higher than zero (i.e., future-focused) in Croats ($W = 2,823, p < 0.001, r_{tb} = 0.58, 95\% \text{ CI } [0.40, 0.72]$), Serbs ($W = 2,883.500, p < 0.001, r_{tb} = 0.58, 95\% \text{ CI } [0.32, 0.72]$), Bosniaks ($W = 3,067, p < 0.001, r_{tb} = 0.57, 95\% \text{ CI } [0.38, 0.71]$), Americans ($W = 2,635, p < 0.001, r_{tb} = 0.55, 95\% \text{ CI } [0.35, 0.70]$), and Moroccans ($W = 5,793, p < 0.001, r_{tb} = 0.52, 95\% \text{ CI } [0.36, 0.65]$). But the personal temporal focus was not significantly different from zero (i.e., the temporal focus was neutral) in Turks, Spaniards, or Chinese (in all cases $p > 0.2$). The results remained after FDR correction. It is interesting to note that this measure of temporal focus rendered an ordering of the cultures that basically reversed the ordering obtained from the Temporal Focus Questionnaire based on temporal values: cultures where people think and attend more strongly to their personal future versus their past also tend to hold stronger past temporal values. However, the correlation of the group rankings between the two temporal focus indexes, although sizeable, was not significant ($N = 8; \tau_b = -0.5, p = 0.1$).

Again, the correlation between group rankings in personal temporal focus and each task only pointed to a connection with time discounting, that in this case reached significance ($\tau_b = -0.79, p = 0.01$), but did not survive FDR correction. All other rank correlations were not significant (in all cases $N = 8$; Self-continuity: $\tau_b = -0.04,$

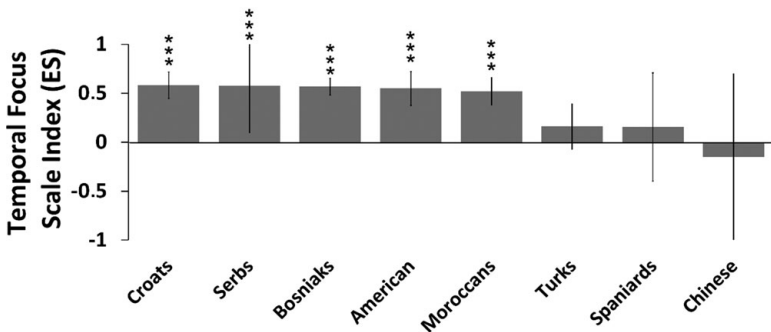


Fig. 7. Bar graph representing the effect size of the difference between the asymmetry index of the temporal focus scale with zero in each culture. Effect sizes are calculated by rank-biserial correlation. The error bars show the 95% Confidence Interval of the effect size. Statistically significant results are marked with asterisks: *** $p < 0.001$.

$p = 0.9$; Time Distance: $\tau b = 0.26, p = 0.4$; Temporal Depth SD: $\tau b = -0.45, p = 0.13$; Temporal Depth Short: $\tau b = -0.11, p = 0.71$; Temporal Depth Mid: $\tau b = -0.19, p = 0.53$; Temporal Depth Long: $\tau b = -0.57, p = 0.06$). To maximize power, we pooled together all participants from cultures with a significant future temporal focus in this measure (Croats, Serbs, Bosniaks, Moroccans, and Americans) and compared their asymmetry indexes in the different tasks with participants from cultures with a neutral temporal focus (Turks, Spaniards, and Chinese). The contrast in personal temporal focus between these two groups of cultures was strong and significant (future-focused: $N = 526$; neutral focus: $N = 288$; $U = 55,835, p < 0.001, r_{\tau b} = 0.26, 95\% \text{ CI } [0.18, 0.34]$). The two groups only differed in two temporal tasks, time discounting (future-focused: $N = 456$; neutral focus: $N = 284$; $U = 56,465, p < 0.01, r_{\tau b} = 0.13, 95\% \text{ CI } [-0.21, -0.04]$) and temporal depth in the mid (not the long) term (future-focused: $N = 554$; neutral focus: $N = 326$; $U = 83,244, p < 0.05, r_{\tau b} = 0.08$). However, after FDR correction only time discounting remained significant. The direction of the effect was contrary to expectations: people from cultures with future personal temporal focus showed symmetry whereas people from cultures with neutral temporal focus showed future asymmetry. To allow for a visual appreciation of this pattern, Supplementary Figure S1 shows the data in Fig. 2 reordered according to their personal temporal focus: from higher (on the left) to lower (on the right) future focus. That personal and value temporal focus dissociate is also supported by a direct comparison between the cultures with neutral versus future personal temporal focus in their value temporal focus, which showed a strong difference ($U = 69,180, p < 0.001, r_{\tau b} = -0.47, 95\% \text{ CI } [-0.53, -0.42]$).

We also pursued individual-level analyses with the personal temporal focus index. Firstly, we computed Kendall's Tau B correlation coefficients to assess its relation to the asymmetry indexes of each task both within each culture and in the overall sample, using only those participants with valid data in the relevant task. The results indicated that personal temporal focus correlated with the self-continuity index ($\tau b = -0.06, p = 0.02, N = 810$) and with the temporal depth index in the mid-term ($\tau b = 0.06, p = 0.03, N = 689$) in the overall sample, but no correlation remained after FDR correction. In the culture-wise analyses, personal temporal focus only correlated with the self-continuity index in Americans ($\tau b = 0.16, p = 0.03, N = 96$) and with the long-term temporal depth index in Croats ($\tau b = 0.16, p = 0.04, N = 89$), but no correlation remained after FDR correction. Moreover, the correlation between value and personal temporal focus was negative but not statistically significant ($N = 812, \tau b = -0.02, p = 0.3$).

3.4. Are the asymmetry indexes correlated with each other? Is there a single factor underlying them?

We finally analyzed the relation between the asymmetry indexes of the different temporal tasks. First, we used Kendall's Tau B correlations with FDR correction (see Table 3). Pooling together all participants, only the correlations internal to the Temporal Depth Task between the short, mid, and long-term indexes were significant. This also occurred within each culture (in all cases, $p_s < 0.01$), with the only exception of the correlation between the short-term and mid-term temporal depths in Croats. In addition, the analysis within cultures also revealed, in the Chinese group, significant correlations between time discounting with both the general index of

Table 3. Kendall's tau correlations between asymmetry indexes and temporal focus indexes

	Self cont. index	T. Discounting index	T. Distance index	T. Depth short index	T. Depth mid index	T. Depth long index	T. Depth SD index	Personal T. Focus index (TFS)
T. Discounting index	$\tau b = -0.04$ $N = 737$							
T. Distance index	$\tau b = 0.03$ $N = 815$	$\tau b = 0.03$ $N = 740$						
T. Depth short index	$\tau b = 0.03$ $N = 688$	$\tau b = -0.01$ $N = 640$	$\tau b = -0.02$ $N = 690$					
T. Depth mid index	$\tau b = 0.00$ $N = 689$	$\tau b = 0.04$ $N = 641$	$\tau b = -0.03$ $N = 691$	$\tau b = 0.49^{***}$ $N = 879$				
T. Depth long index	$\tau b = -0.01$ $N = 689$	$\tau b = 0.06$ $N = 641$	$\tau b = -0.06$ $N = 691$	$\tau b = 0.30^{***}$ $N = 879$	$\tau b = 0.48^{***}$ $N = 880$			
T. Depth SD index	$\tau b = -0.01$ $N = 689$	$\tau b = 0.06$ $N = 641$	$\tau b = -0.06$ $N = 691$	—	—	—		
Personal T. Focus index (TFS)	$\tau b = 0.06$ $N = 810$	$\tau b = -0.02$ $N = 739$	$\tau b = -0.02$ $N = 814$	$\tau b = 0.05$ $N = 688$	$\tau b = 0.06$ $N = 689$	$\tau b = 0.00$ $N = 689$	$\tau b = -0.01$ $N = 689$	
Value T. Focus index (TFQ)	$\tau b = 0.04$ $N = 811$	$\tau b = 0.08^{***}$ $N = 738$	$\tau b = -0.06$ $N = 815$	$\tau b = 0.01$ $N = 874$	$\tau b = 0.01$ $N = 875$	$\tau b = 0.01$ $N = 875$	$\tau b = -0.00$ $N = 875$	$\tau b = -0.02$ $N = 812$

Note. Statistically significant results after false discovery rate correction for multiple comparisons are marked with asterisks: $^{***}p < 0.001$.

Table 4. Exploratory factor analysis for the asymmetry indexes

Factor loadings	Factor 1	Uniqueness
Self-continuity index		0.99
Time discounting index		0.99
Time distance index		0.99
Temp depth short index	0.67	0.55
Temp depth mid index	0.95	0.09
Temp depth long index	0.68	0.54

Note. The minimum residual extraction method was used in combination with an 'oblimin' rotation. The loadings below 0.3 are not shown.

temporal depth ($N = 91$, $tb = 0.20$, $p = 0.007$) and the long-term index ($N = 91$, $tb = 0.21$, $p = 0.006$), as well as between the mid-term temporal depth index and time distance ($N = 94$, $tb = -0.21$, $p = 0.007$). All of these correlations remained after FDR correction. Other significant correlations that became insignificant after FDR correction were: a correlation between time discounting and the mid-term temporal depth index ($N = 88$, $tb = 0.20$, $p = 0.01$) and a correlation between self-continuity and the short-term temporal depth index ($N = 88$, $tb = 0.18$, $p = 0.03$) in the Turks; a correlation between time distance and the short-term temporal depth index in Americans ($N = 96$, $tb = 0.17$, $p = 0.047$); and correlations between time distance and both time discounting ($N = 87$, $tb = -0.16$, $p = 0.04$) and the general temporal depth index ($N = 74$, $tb = 0.18$, $p = 0.03$) in Serbs.

Second, we carried out an exploratory factor analysis to check if there was a single temporal construct underlying the temporal asymmetries. The minimum residual extraction method was used in combination with an oblimin rotation. The measures introduced in the analysis were the self-continuity index, the time discounting index, the time distance index, and the three asymmetry indexes from the short-, mid-, and long-term temporal depth. The results revealed a factor shared by the three indexes of the temporal depth, but the rest of the indexes were unrelated, having more than 99% uniqueness each one (see Table 4). This indicates that there is not a common underlying dimension to the asymmetry indexes of the time tasks. This result was expected given the lack of correlation found between asymmetry indexes (see Table 3).

4. Discussion

In the present work, we investigated the temporal asymmetry between the past and the future in eight Western, Middle Eastern, and Far Eastern cultures varying in temporal focus, by means of a battery of temporal tasks, in order to answer four questions: (1) Is there asymmetry or symmetry toward the past and the future in each task? In three out of four tasks, we found an overall future asymmetry, which varied strongly in size, while in one task there was symmetry. There was a strong asymmetry toward the future in self-continuity (the future self seems more similar to the present self than the past self), and much smaller asymmetries in time discounting (future rewards are discounted less than past rewards) and temporal depth (future horizons are deeper than past horizons, but only when we ask about long-term horizons). We did not find an asymmetry in time distance. (2) Do past and future hold a negative or a positive relation in the mind? Our results indicated

that past and future maintain a positive relation in the mind: the past and future versions of the tasks were strongly positively correlated with each other, both overall and within cultures with very few exceptions. (3) Do the putative asymmetries depend on temporal focus in such a way that people in more future-focused cultures show stronger future-asymmetries than those in past-focused cultures (who may even show past asymmetry)? There was not a gradual effect of temporal focus over the cultures in the degree of asymmetry shown in any of the tasks, neither when temporal focus was operationalized as the value given to past (tradition) versus future (progress) nor when it was operationalized as the amount of attention and thinking devoted to the personal past versus future. Unexpectedly, the two measures of temporal focus dissociated: Cultures that were past-focused in terms of temporal values (Moroccans, Bosniaks, Croats, and Serbs) showed strong future focus in terms of personal past and future, and cultures that were strongly future-focused in terms of temporal values (Spaniards, Chinese, and Turks) showed a neutral personal temporal focus. Only when cultures with qualitatively different kinds of temporal focus in each index were pooled together in two groups, we could observe an effect of temporal focus on only one task: time discounting. As expected from the dissociation between temporal focus indexes, this effect was in opposite directions: future asymmetry in time discounting occurred in cultures with future value temporal focus and neutral personal temporal focus, whereas symmetry was found in cultures with past value temporal focus and future personal temporal focus. When we looked at the different cultures, these findings seemed to be driven mainly by the Chinese. Individual-level correlations over the whole sample only rendered a correlation between value temporal focus and time discounting. (4) Are the putative asymmetries in the different tasks correlated with each other? The asymmetry indexes of the tasks were not related to each other, nor did they share a single underlying temporal construct. In the following, we discuss the present findings in the context of previous literature, and we discuss the implications and limitations of the present work.

4.1. Temporal asymmetries

Temporal asymmetry toward the future varied with tasks and cultures. First, the self-continuity task showed a future asymmetry both overall and in some cultures. The asymmetry found in Americans in self-continuity is inconsistent with the symmetric pattern found in Americans by Rutt & Löckenhoff (2016; although they did show asymmetry related to time distance in a different and implicit measure of self-continuity). Our results are also inconsistent with the past-asymmetry shown by Ji et al. (2019) in both Chinese and Euro-Canadians (participants felt more similarity with their past selves than with their future selves). On the contrary, our findings in the Chinese participants are consistent with Guo & Spina's (2019) findings of symmetry in the Chinese.

We also found a smaller overall future-asymmetry in time discounting (people discounted less a future than a past reward), which fits with results by Molouki, Hardisty, & Caruso (2019), studies 1 and b). However, when we looked within each culture, we did not find asymmetry in most of them (only in the Chinese), which agrees with the symmetrical patterns found in previous studies on past and future time discounting (Bickel et al., 2008; Molouki, Hardisty, & Caruso, 2019, study 2a;

Pope et al., 2019; Stieg & Dixon, 2007; Yi, Gatchalian, & Bickel, 2006) as well as with the temporal value symmetry observed by Burns et al. (2019) in adults in a different task. It is possible that the asymmetry in time discounting is a small effect that requires larger samples to be found. In addition, Kvam, Baldwin, & Westgate (2022) have recently shown that some factors can affect asymmetry in time discounting. They found an overall pattern of future asymmetry which tends to disappear as the size of the reward is reduced and time increases, giving rise first to a symmetrical pattern and then to a past asymmetry. Unfortunately, procedural differences make it difficult to compare Kvam, Baldwin, & Westgate's (2022) results with previously reported and present results.

In temporal depth we also found an overall future asymmetry: people's horizons into the future were deeper than into the past. This agrees with the future asymmetry found by Bluedorn (2002). However, in the analyses within each temporal depth, we only found a small future asymmetry in the long term, but not in the mid and short terms. Furthermore, we did not find asymmetry in most cultures. The only exception was China, where we found a future asymmetry in long-term depth.

In contrast, our data about temporal distance showed symmetry: the participants perceived a month into the past as equally close to the present as a month into the future. So, we did not replicate the future asymmetry found by Caruso et al. (2013) in their experiment 1a with Americans nor the future asymmetries found by Gan et al. (2017) with Chinese participants (in various temporal distances, including 1 month). The present results are also inconsistent with the asymmetry observed in the UK adults (as well as adolescents and children) by Burns et al. (2019). Our data from the rest of the cultures constitute six additional independent replications where we found no asymmetry. When all data were pooled together, present results provide a statistically powerful test: there was no asymmetry in temporal distance. Thus, our data question the Temporal Doppler Effect, joining other failures of replication (Ji et al., 2019). Studies of how forward motion affects this asymmetry have also provided conflicting results (Aksentijevic & Treider, 2016; Liefgreen, Dalton, & Maguire, 2020; Loeffler, Raab, & Cañal-Bruland, 2017).

One possible interpretation that integrates most of the present findings is that the asymmetry between past and future is a small effect that becomes stronger when longer temporal intervals are considered. As shown, the greatest future asymmetry was found in self-continuity, where participants had to think over a 10-years interval; the asymmetry in temporal depth was only found in the long term; and we did not observe any significant temporal asymmetry when the participants judged a temporal distance of one month. Although it is difficult to bring the time discounting task to bear on this question because it conflates temporal intervals with monetary amounts, it is suggestive that we observed a small asymmetry in this task whose maximum interval is roughly two months and a half. This interpretation is in line with Rutt & Löckenhoff's (2016) data from implicit measures of self-continuity, which showed that the longer the temporal distance in implicit self-continuity (from 1 month to 10 years), the greater the future asymmetry (however, explicit self-continuity showed symmetry). This interpretation integrates present findings and, possibly, other findings in the literature, providing some support for the dominant view: there is a future asymmetry in temporal thought, though small and only observable under conditions involving long intervals. This possibility can be directly tested in future studies that manipulate temporal magnitude within each of the tasks.

4.2. *Positive versus negative relation between past and future*

The past and future versions of all the temporal tasks in all cultures were positively correlated, regardless of whether or not there was asymmetry, supporting the idea that past and future have a positive relation in the mind. This contradicts the temporal motion interpretation that Caruso et al. (2013) provided for the Temporal Doppler Effect: if the future asymmetry arises because of the forward motion of ego along the mental time line from past to future, as the distance to a future event decreases, the distance to a past event increases. The positive relation between the past and future is also unexpected from the temporal focus hypothesis under the assumption that resources used to pay attention and think about the past and the future are limited. On the contrary, the present results show clearly that past and future are positively related in the mind. There is some prior consistent evidence about the positive relation between the past and future in temporal depth (Bluedorn, 2002), self-continuity (Ji et al., 2019), and time discounting (Kvam, Baldwin, & Westgate, 2023; Molouki, Hardisty, & Caruso, 2019). The fact that this positive correlation arises in all the temporal tasks suggests that it reveals an organizing principle of temporal cognition and is consistent with approaches such as Ji et al. (2009, 2019), which suggests that people (and cultural groups) vary in the attention they pay to temporal context, both past and future, versus the present.

4.3. *Cross-cultural temporal focus and temporal asymmetries*

We measured temporal focus in two different ways: as the balance between values of past (tradition) and future (progress) and as the amount of attention and thinking devoted to the personal past and future. Either way, we found very little evidence in support of the idea that cross-cultural differences in temporal focus can affect temporal asymmetries in most tasks. We only found an effect of temporal focus on time discounting when cultures with qualitatively different temporal focus were pooled together, thus allowing a statistically powerful contrast. This effect took the expected shape regarding value temporal focus: cultures with future focus showed future asymmetry in time discounting whereas cultures with past focus showed symmetry (although there was not a reversal). However, it took an unexpected shape when considering personal temporal focus: past focused cultures showed future asymmetry whereas cultures with neutral focus showed symmetry. In the correlational analyses at the individual level, only value temporal focus correlated with time discounting over both the whole sample and in Serbs.

All in all, present results open new and important questions. An important finding of the present study is that the two operationalizations of temporal focus (temporal values vs. personal past-future) behaved in contrasting ways. The cultures in which people gave more importance to traditional values (vs. progress) also devoted more attention to their personal future (vs. past). The present study is the first, to our knowledge, that allows a direct comparison of both measures of temporal focus, and the results suggest that they capture two different kinds of temporal focus. Thus, our results call for a deeper study of the two kinds of temporal focus, which so far were implicitly considered to be alternative ways to measure the same construct.

The contrast between these two measures of temporal focus may offer some help in reconciling some prior results. In our data, Americans were more future-oriented than Chinese in personal temporal focus ($U = 3,170.5$, $p < 0.001$, $r_{rb} = -0.31$, 95% CI

[−0.45, −0.16]), but Chinese participants were more future-oriented than Americans in value temporal focus ($U = 9,227.5$, $p < 0.01$, $r_{tb} = 0.21$, 95% CI [0.07, 0.34]). As present results show, this may affect different temporal tasks in divergent ways. Although it is an open question whether this possibility will prove valuable, what clearly follows from present data is that researchers should clarify what kind of temporal focus they are talking about and that they should refrain from assuming that culture has a certain kind of temporal focus on an a priori basis.

4.4. One versus multiple underlying dimensions of temporal cognition

Finally, the present study does not support the idea that the different temporal tasks tap onto the same underlying construct: There was a lack of correlation between the asymmetry indexes in the different temporal tasks, both overall and in the culture-wise analyses (with only three exceptions in the Chinese), and no common factor was found in the exploratory factor analysis. The selected tasks seem to rely on different underlying dimensions of temporal thought that are not constrained to covary. This adds to recent research that has shown that even just one of the dimensions, self-continuity, can be divided into different factors (Bixter et al., 2020). More research is needed to reveal the underlying structure of temporal cognition and how it is captured by different tasks.

5. Conclusions

The present study undertook an examination of unprecedented breadth of the question of temporal asymmetry and its relation to temporal focus across cultures by using a battery of four temporal tasks and empirically measuring temporal focus in two different ways in eight cultural groups, from Western to Middle Eastern to East Asian, varying widely in temporal focus and amounting to a total sample size of over 1,000 participants. We obtained evidence for some important generalizations about temporal thought. First, people around the world think asymmetrically toward the future (vs. the past). This effect varies widely in size across tasks, possibly depending on the length of the temporal distances used in the task. Second, in all tasks and cultures, temporal thought about the past is positively linked to thought about the future. Third, cross-cultural and individual variations in temporal focus do not have an effect on temporal asymmetries, with the only exception of time discounting. Fourth, more research is needed on the construct of temporal focus, which may dissociate into two (perhaps more) different kinds. Finally, temporal thought is a multi-faceted phenomenon and different tasks may tap onto different underlying dimensions. All in all, present findings pose an important challenge to temporal motion and temporal focus accounts. As in most prior studies, these conclusions are limited to young participants, mostly university students, and further research is needed to establish their wider generality.

Supplementary Materials. To view supplementary materials for this article, please visit <http://doi.org/10.1017/langcog.2022.5>.

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Data availability statement. All materials, datasets, and a script with detailed explanatory comments for the statistical analyses (developed in R version 4.1.1, see R Core Team, 2021) of the study reported in this article are publicly available at Open Science Framework (<https://osf.io/bwt5r/>). The present work is fully reproducible using those materials.

Author contributions. All the authors assisted in study design and data collection, and provided critical revisions to the manuscript. C.C.-R. and J.S. analyzed and interpreted the data and drafted the manuscript. This work is part of the doctoral dissertation of the C.C.-R. under the supervision of the J.S. in the Psychology Doctoral Program at the University of Granada.

Conflict of interest. The authors declare that they have no conflict of interest.

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