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Master's Thesis:

Is Face Age Mapped Horizontally into Space in a Culture with Mixed Reading Habits? A Cross-Cultural Study

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Abstract

This study investigates the Spatial-Temporal Association of Response Codes (STEARC) effect using facial age stimuli in a cross-cultural context involving Iranian and Italian participants. The research aims to explore how mixed reading habits influence the STEARC effect. Based on previous findings, we hypothesize that Italian participants, accustomed to a left-to-right orthographic system, will show faster responses to younger faces on the left and older faces on the right. Conversely, Iranian participants, who read from right to left but have mixed reading habits, might exhibit an opposite or weakened STEARC effect. The study also examines the temporal distance effect, predicting that reaction times will decrease as the age difference between target and reference faces increases. Our results confirm a significant Inverted STEARC effect in the Iranian sample, indicating for the first time that mixed reading habits can influence spatial-temporal associations with face age. The consistent observation of the distance effect across both cultures supports a universal cognitive mechanism in age perception. Additionally, the Temporal Diagram Task (TDT) and Temporal Focus Questionnaire (TFQ) provided insights into explicit and implicit temporal orientation, showing that cultural factors significantly influence spatial-temporal mappings. While no significant correlation was found between temporal focus and the STEARC effect, the TFQ results revealed that a majority of Iranians are future-focused. These findings suggest that cultural and linguistic factors play a crucial role in cognitive processes involving time and space, contributing to a deeper understanding of how reading and writing practices shape our perception of temporal and spatial associations.

Keywords: STEARC-Effect; Time perception; Social cognition; Face age; Temporal orientation

Introduction

Background

The concept of time, an essential element of the human condition, has consistently fascinated scientists and intellectuals from many fields of study. One interesting finding is related to the spatial representation of time. Increasing evidence suggests that various inputs linked to time may be mapped into hypothetical mental timelines that are aligned with three spatial axes (Bender & Beller, 2014; Bonato et al., 2012; Dalmaso et al., 2023): lateral (left-right), sagittal (back-front) and vertical (down-up).

The relationship between time and space has been extensively studied using behavioral tasks. Some of these tasks involve the quick categorization of a centrally presented stimulus based on its temporal meaning, such as “past” vs. “future”, “brief” vs. “long” or “before” vs. “after”. Usually, responses are provided by hitting buttons that are positioned in such a way that one button is located on one side of the spatial axis being studied and the other button on the opposite side. As an example, for the representation of time on the lateral axis, a response button located to the left vs. another located to the right allows two potential time-space congruency effects (Conson, 2008; Ishihara et al., 2008; Vallesi et al., 2008): 1- faster and/or more accurate left- and right-side responses to past/brief/before and future/long/after stimuli, respectively, compared to the opposite; 2- faster and/or more accurate left- and right-side responses to future/long/after and past/brief/before stimuli, respectively, compared to the opposite. The STEARC (Spatial-Temporal Association of Response Codes) effect, as described by Vallesi et al. (2008), refers to the benefit derived from one of the two time-space mappings. This advantage is seen as indicative of a spatial representation of stimuli that are connected to time. For instance, Vallesi et al., 2008 (see also Scozia et al., 2024; Weger & Pratt, 2008) observed that individuals responded more quickly to stimuli that involved past/brief/before concepts using the left-side key compared to the right-side key, and more quickly to stimuli that involved future/long/after concepts using the right-side key compared to the left-side key. They interpreted this finding as a proof of a left-to-right spatial representation of time.

This STEARC effect is similar to the SNARC (Spatial-Number Association of Response Codes) effect. The SNARC effect refers to the spatial representation of numbers along a theoretical mental number line oriented laterally, sagittally, or vertically (Aleotti et al., 2020; Dehaene et al., 1993). Extensive research has been conducted on the SNARC effect (for a review, see Wood et al., 2008). Regarding the lateral representation of numbers, even if some researchers employing non-symbolic numerical magnitudes, such as dots, have observed a representation of low numbers on the left and high numbers on right in newborns (De Hevia et al., 2017) and nonhuman animal species (Rugani et al., 2015), it seems that individuals' reading habits can impact this representation. Dehaene et al. (1993) observed that, while French participants mapped low and high numbers to the left and right, respectively, Iranian participants showed an opposite pattern, unless they had been exposed to a left-to-right orthographic system during a long period of time. In another study, Shaki et al. (2009) observed a left-to-right mapping of numbers in Canadian participants (who read from left to right), an opposite pattern in Palestinian participants (who read from right to left reading) and an absence of pattern in Israeli participants (who possess an orthographic system that uses both right-to-left and left-to-right directionalities). This implies that the SNARC effect may possess cultural origins. To reconcile these results, it has been suggested that distinct brain asymmetries might impact the processing of magnitudes (De Hevia et al., 2014; Vallortigara et al., 2018; Felisatti et al., 2020), but that other variables, such as reading habits, may exert further influence on this mapping (Walsh et al., 2003; Proctor et al., 2006; Myachykov et al., 2013).

Similarly, it seems that the mapping of time over the lateral axis is linked to the direction of writing and/or reading habits. Effectively, a past-left/future-right mapping has been observed in participants from cultures that read from left to right and a future-left/past-right mapping in participants from right to left reading cultures (Fuhrman & Boroditsky, 2010; Ouellet et al., 2010; Pitt & Casasanto, 2020; Tversky et al., 1991). It has been hypothesized that the sensory-motor experiences associated with the passing of time while reading (e.g., in English, scanning with the eyes from left to right or seeing the text already read on the left and the text to be read on the right) would foster this spatial mapping (e.g., Ouellet et al., 2010).

The STEARC effect has been extensively studied with various stimuli. These stimuli can be categorized into two primary groups: first, the physical duration of visual or auditory stimuli (Beracci et al., 2022; Dalmaso et al., 2023; Ishihara, et al., 2008; Mariconda et al., 2022; Vallesi et al., 2008); second, abstract concepts of time conveyed through words indicating past or future actions/events (e.g., yesterday vs. tomorrow; Santiago et al., 2007; Ouellet et al., 2010; Santiago & Lakens, 2015), or with images representing different historical periods (e.g., ancient vs. futuristic cities; Miles et al., 2011). An area that has received little research attention is the potential for documenting a STEARC effect in a social context, such as the presentation of face stimuli at various stages of development.

Faces are perhaps the most informative social cues that we are required to observe and comment on regularly, and the age of a face is a particularly significant social factor. There are two primary reasons to explain why we are highly proficient in determining the age of a person based on her/his facial features. First, extrapolating the age of a face is crucial since our behavior during social encounters is often influenced by the age of others. For example, we are likely to react differently while engaging with a young compared to an elderly person. Second, face age is a social aspect that exhibits a gradual and consistent alteration over time, resulting in a generally stable and distinct cognitive representation of faces belonging to different age groups. For instance, the facial characteristics of a kid may be readily differentiated from those of an elderly individual. Due to these factors, the age of a person's face should serve as a very effective stimulus to evoke a STEARC effect in a social context. Previous studies (Boroditsky et al., 2011; Kolesari & Carlson, 2018; Xiao et al., 2018) have provided evidence of a STEARC effect in response to social stimuli, such as pictures of a person at different ages. These studies have shown that the term "early" is linked to the left and top portion of the space, while "late" is associated with the right and bottom portion of the space. Nevertheless, the aforementioned studies also used nonsocial cues, such as an image depicting a fruit before and after being bitten, and the data of the social stimuli were analyzed together with the data of the nonsocial stimuli. Consequently, it is impossible to evaluate the precise impact of the social stimuli on the participants' performance.

Dalmaso and Vicovaro (2021) investigated the spatial mapping of facial ages on a horizontal axis by utilizing a range of faces from 20 to 80 years of age. The results demonstrated a reduction in reaction latencies as the difference between the target and reference faces increased, suggesting the successful processing of the magnitude of the age of the faces. Nevertheless, they did not observe a STEARC effect. They hypothesized that this absence of an effect might be due to the utilization of different identities between the target and reference faces in the temporal comparison task. According to the authors, the participants might have used a representation based on the exemplars rather than a generic representation. In a recent study, Dalmaso et al. (2023) carried out three experiments to further investigate the spatial representation of facial age. The task assigned to the participants involved determining whether the age of a centrally presented target face was younger or older than the age of a reference face that was 40 years old. Critically, both the target and the reference faces belonged to the same identity (a male avatar face), with its age being intentionally altered. In Experiment 1, the manual answers were obtained by pressing a button to the left or the right. A congruency effect between the age of the faces and the location of the responses was observed. Specifically, younger and older faces were responded faster to the left and right, respectively, compared to the opposite. This finding aligns with the well-documented STEARC effect. In addition, it was observed that reaction latencies decreased significantly when the difference between the age of the target face and the age of the reference face grew, indicating the presence of a temporal distance effect. Given the current limitations in the literature on the STEARC effects in connection to face ages, as well as the fact that it has not been investigated whether or not this spatio-temporal mapping is the opposite in participants from right-to-left reading cultures, it is necessary to carry out more research.

To address this issue, we planned to use a task akin to the one devised by Dalmaso et al. (2023) to investigate the STEARC effect with facial age stimuli in a new population, native Iranian participants. This research is important due to its capacity to either replicate prior findings (see Dalmaso et al., 2023) and provide new perspectives. We predict that Iranians, who are familiar with a right-to-left writing system, should be faster on the right and left sides for younger and older faces, respectively, compared to the opposite. However, since the Persian/Farsi language of the Iranians is a language that exhibits mixed reading characteristics (while the words are written or read in a right-to-left manner, numbers are written or read in a left-to-right manner), it is possible that the Iranian participants will not show any significant STEARC effect or that this effect will be weaker compared to the Italian participants in Dalmaso et al. (2023). In line with this hypothesis, it has been demonstrated that the mixed reading habits of the Iranian participants can weaken the spatial mappings of concepts on the lateral axis. For instance, Rashidi-Ranjbar et al. (2014) failed to observe a spatial representation of numbers with Iranian participants. Furthermore, following the distance effect proposed by Moyer and Landauer (1967), it was anticipated that there would be a linear reduction in reaction latencies as the disparity between the age of the target face and the reference face rose in both groups (Dalmaso & Vicovaro, 2021).

In addition, as a secondary goal, we planned a preliminary study to investigate the spatialization of time in an explicit task, using the Temporal Diagram Task. In this task, participants are asked to arrange past and future events depicted in a schematic drawing. This cognitive tool is designed to assess individuals' spatial representations of time in an explicit way. We will be drawing on previous research (Casasanto, 2009; Li & Cao, 2017; Callizo-Romero et al. 2020) to guide our preliminary examination and will use these results to compare the mapping of time in an explicit vs. a more implicit task. Furthermore, we will use the Temporal Focus Questionnaire to measure the degree of importance placed on the past (e.g., traditions) vs. the future (e.g., progress). According to the Temporal Focus Hypothesis (TFH), cultural or subcultural factors can foster the participants to pay more attention to a temporal orientation and it has been demonstrated that the spatial arrangement of past and future events can be modified by the attention given to these temporal orientations (Callizo-Romero et al. 2020, de la Fuente et al., 2014). The central focus of this part is the Temporal Focus Hypothesis (TFH), which proposes that the spatial arrangement of past and future events is modified by the attention given to these temporal orientations (de la Fuente et al., 2014). However, these temporal focus effects have been observed only on the sagittal axis (Callizo-Romero et al. 2020, de la Fuente et al., 2014).

Hypotheses

We hypothesize that the STEARC effect will be influenced by cultural and linguistic factors. Specifically, it is hypothesized that Iranians, who are users of a right-to-left orthographic system, will exhibit the opposite pattern as compared to Italian, i.e., they will show quicker right-side and left-side reactions respectively when responding to younger and older faces. Alternatively, it is hypothesized that there may be no significant effect or a reduced effect in the Iranian population due to mixed reading habits. To study the direction of the reading hypothesis, it will be necessary to ask the Iranian participants about their English language and music notes (music notes in Iran are read from left to right) reading proficiency and habits, as they relate to left-to-right reading and writing habits. Italian participants will also be asked about their reading habits and proficiency in other languages. Although our experiments are conducted in the participants' first languages, a recent study by Malyshevskaya et al. (2024) showed that the STEARC effect is influenced by language proficiency, with bilinguals exhibiting a stronger bias in their second language based on their proficiency. This underscores the importance of controlling for language proficiency in our study, even when focusing on the participants' native languages, to ensure a comprehensive understanding of their reading and spatial-temporal association habits. Therefore, we want to control for English proficiency in Iranian participants, as English is the most popular second language learned in Iran. Because the mapping being studied is on the lateral axis, handedness will also be controlled, but it is not expected to modulate the STEARC effect. Furthermore, we expect to observe a linear decline in reaction times when the age difference between the target and reference faces increases. Regarding the Temporal diagram task, we anticipate observing a phenomenon similar to the STEARC Effect. Specifically, Iranians should tend to place future events in the left box and past events in the right box. Concerning the Temporal focus questionnaire, we have no specific expectations. Our goal is to simply observe the data as a preliminary observation to assess the possibility of doing subsequent investigations, particularly focusing on the sagittal axis.

Objectives

A. Investigating the impact of cultural and linguistic variables on the STEARC effect on the perception of face ages on the horizontal axis.

B. Replicating previous findings on the STEARC effect.

C. Investigating the influence of mixed reading/writing habits, particularly with face age stimuli, to reveal possibly novel or distinct results.

D. Comparing the mapping of time in an explicit vs. implicit context.

Method

Participant

The sample size was determined following the same approach used by Dalmaso et al. (2023). Since we planned to analyze the data using linear mixed-effects models with items and participants as random variables, we followed recommendations by Brysbaert and Stevens (2018). These guidelines recommend 1600 trials per experimental condition in repeated-measure designs for statistical power. We needed at least 27 participants per group to gather 60 trials per condition for each participant.

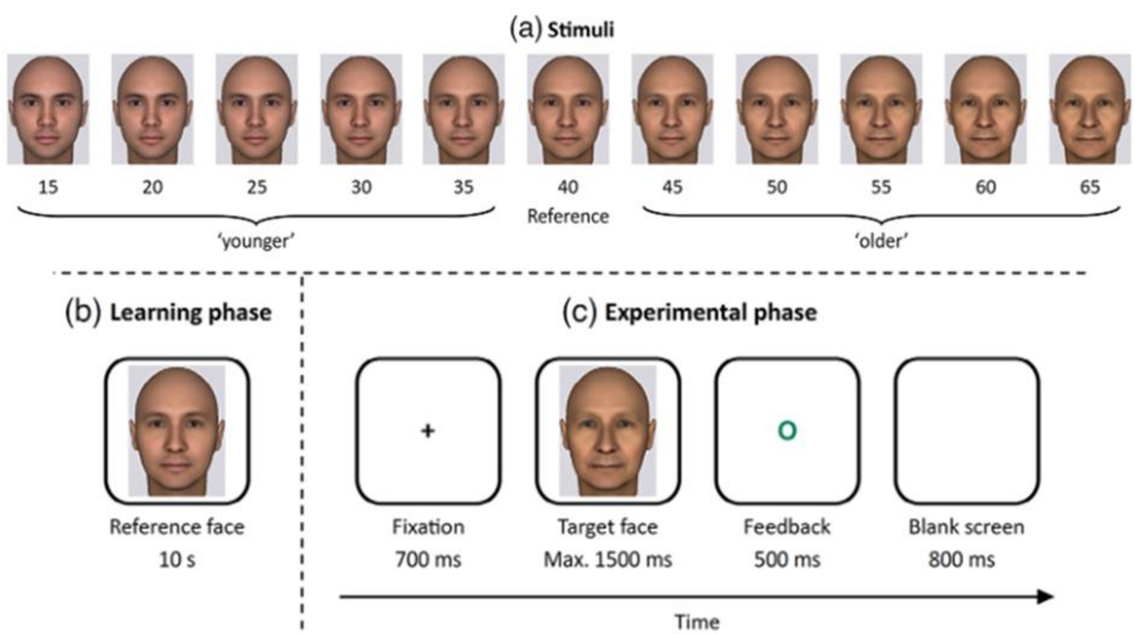
The final sample involved a group of 32 participants (66% females and 34% males; mean age: 23.41 years; *SD* = 2.01). They were mostly undergraduate or master's psychology student. Written informed consent was obtained individually from each participant before testing. The study was approved by the Ethics Committee for Psychological Research at the University of Padova (protocol 3881). This end of master's thesis (TFM) is part of a project preregistered on OSF (https://osf.io/ckw7j/), where it was planned to carry out the experiment with a group of Italian participants as well. However, Italian results are not yet available due to time constraints. Therefore, we report only the Iranian outcomes and compare them with the findings of Dalmaso et al. (2023) in the Italian population. To gather demographic data related to musical knowledge, mathematics engagement, and English proficiency, participants were required to fill out a questionnaire at the start of the study. The following inquiries were part of the questionnaire: "Please rate your English level from 1 to 7," "If you have musicianship skills, please rate the amount of your daily music practice from 1 to 7," "Please rate your English skills like reading and writing in your daily life from 1 to 7," and "If you are a student, please write your study field; if you work, write your specialized field" (the purpose of this question was to determine if participants are engaged in daily mathematical practice).

Materials

The STEARC Effect Task

The stimuli include 11 face stimuli (300 × 400 pixels) from the same model (Dalmaso et al., 2023). These faces were created with the FaceGen Modeler program (https://facegen.com/; version 3.4.1), which enables the production of well-controlled realistic faces. Faces were additionally calibrated for brightness and spatial frequency using the SHINE_color MATLAB toolbox (Dal Ben, 2021). To rule out any social confounding effects, the face belonged to a White slightly tanned individual (see also Dalmaso et al., 2023), without hair or any other aspect that could lead to interpreting the face to be from an Italian or Iranian person. The face stimuli represent the model at 11 distinct ages, spanning from 15 to 65 years, with a 5-year delay between each age. The face of the model at the age of 40 serves as the reference stimulus for the age classification test (see Figure 1). As a result, the remaining faces are either younger than the reference (ages 15, 20, 25, 30, and 35) or older than the reference face (ages 45, 50, 55, 60, and 65). The backdrop color is set to white. The experiment was programmed with PsychoPy software (Peirce et al., 2019) and conducted online via Pavlovia (Bridges et al., 2020). Additionally, after the experiment, a single question was asked to the participant to determine if the face was either representative of an Italian or an Iranian individual on a scale from 1 (total association with Italian culture) to 7 (total association with Iranian culture).

Figure 1. *Experimental Design and Task Procedure*



Note. The experiment utilizes face stimuli, which are illustrated in panel A. The task comprised a learning phase (panel B), where participants were instructed to see the reference face for 10 seconds, and a comparison task (panel C), where participants had to classify the target face as either younger or older than the reference (Dalmaso et al. 2023).

Temporal diagram Task

The objective of the temporal diagram task involves assessing the spatial arrangement of the future and the past along the horizontal axis explicitly. The concept was originally proposed by Casasanto (2009) for valence stimuli and then modified for the temporal domain by de la Fuente et al. (2014). In this assignment, the participant is presented with a basic schematic illustration (see Figure 2), accompanied by an explanation that the figure shown in the illustration visited an animal-loving friend yesterday and will visit a plant-loving friend tomorrow. Participants are then instructed to put the first letter of the word "animal" in the box that best depicts past events and the first letter of the word "plant" in the box that best indicates future occurrences. Four versions of the task have been created to counterbalance the mentioned order of animals and plants, and their combinations with future and past events. In the online version of this task, we asked participants to select between two options: 1. Placing animals in the right box and plants in the left box; 2. Placing plants in the right box and animals in the left box. Consequently, the task involves conducting a single binomial trial. To enhance cultural familiarity, we modified the name of the schematic illustration in the associated story for Iranian participants to "Ali," which is a widely used name in Iran.

Figure 2. *The Figure used in the temporal diagram task*

Temporal Focus Questionnaire

The measurement tool known as the Temporal Focus Questionnaire, which was developed by de la Fuente et al. (2014), assesses cultural temporal values by evaluating participants' level of agreement with values that are connected to the past and future. The scale comprises a total of 20 elements, with an equal distribution of 10 items representing past values and 10 items representing future-related values. Each item is accompanied by a Likert scale that spans from 1 (indicating a complete disagreement) to 9 (indicating a complete agreement). No item is explicitly religious. The past and future focus indices were calculated by taking the average of the ratings assigned to all the items within each category. According to de la Fuente et al. (2014), a TF Index was calculated by subtracting the mean of past-focused items from the mean of future-focused items and then dividing this difference by the sum of the means of both future-focused and past-focused items. The TF Index quantified the extent to which each participant's values aligned with either past-related or future-related perspectives, ranging from -1 (indicating a heavy emphasis on the past) to +1 (indicating a strong emphasis on the future). The TF Questionnaire has a Cronbach's alpha of 0.85 in the past scale and 0.63 in the future scale.

Edinburgh Handedness Inventory (EHI)

The Edinburgh Handedness Inventory (EHI) Short Form (4 items) developed by Veale (2014), is a tool with excellent reliability (Cronbach's $\alpha = 0.93$) and factor score determinacy (0.97) for assessing handedness preference, addressing concerns of over-categorizing mixed-handers and providing a brief, effective assessment. The scoring of this tool involves assessing hand preference for four everyday tasks using a Likert scale. Participants indicate their preference for each task as "always right," "usually right," "both equally," "usually left," or "always left". The scale ranges from -100 to +100, indicating a significant preference for either the left or right hand.

Procedure

At the beginning of the experiment, which started with the STEARC effect task, participants were instructed to direct their attention towards the reference face, which was positioned in the center of the screen for 10 seconds, accompanied by the following sentence positioned above the face: "This individual is 40 years old". Subsequently, the trial began with the presentation of a black fixation cross (Arial font, letter height 0.085 norm) at the center of the screen during 700 ms. It was followed by the target face, presented in the center of the screen during 1500 ms or until a response was done. Afterward, a visual feedback (a green "O" to indicate a right response, a red "X" to indicate an erroneous response, or the phrase "Too slow" to indicate a missed response) was displayed for 500 ms. The feedback was be presented in Arial font and the letter height was 0.065. Finally, a blank screen was displayed for 800 ms.

Participants were told that they needed to be as fast and as accurate as possible to classify the target face as either younger or older than 40 years (i.e., the reference face). Participants were instructed to provide their response by pressing one of two horizontally aligned keys: the "D" key using the left index finger and the "K" key using the right index finger. The experiment was divided into two main blocks: congruent and incongruent blocks. In the congruent block, participants had to respond to younger faces using the left key and to older faces using the right key. Conversely, in the incongruent block, the opposite response mapping was used. The order of the two blocks was counterbalanced across participants. Within each block, 120 experimental trials were presented to the participants, resulting in a total of 240 experimental trials. Each block was preceded by a practice block consisting of 10 trials, resulting in a total of 20 practice trials. Each face was displayed an equal number of times and in a random sequence in both the experimental and the practice blocks.

After finishing the STEARC effect task, participants were required to respond to a face perception question using a 1 to 7 Likert scale. The purpose of this question was to determine whether they perceive the reference face as Iranian or Italian. A rating of 1 indicates a perception of the entire Iranian identity, while a rating of 7 indicates a perception of complete Italian identity. After this section, participants were instructed to participate in the Temporal diagram task, complete the temporal focus questionnaire, and fill out the Edinburgh Handedness Inventory questionnaire.

Results

The English proficiency of the participants varied from Elementary to Pre-Intermediate levels. It is worth mentioning that none of the participants exhibited professional expertise in music. They also lacked strong mathematical skills and did not engage in daily mathematical practice.

STEARC effect

We began our response times (RTs) analysis by removing missed responses, which accounted for 0.95% of the trials. Next, we also removed incorrect responses (7.91% of trials) and analyzed them separately. For each condition, we excluded trials that deviated by over 3 standard deviations from the means, accounting for 1.48% of the trials. The analysis employed mixed-effects models, using the lme4 R package (Bates et al., 2015).

We compared model fit using a likelihood ratio test, ranging from a simple null model to a complex saturated model. The model that best fit the data included both the response side and age category as fixed interacting factors. The model included random slopes for age category and response side for each participant. We used lmerTest R package (Kuznetsova et al., 2017) for the Type I ANOVA examination of our model, employing Satterthwaite's approximation for degrees of freedom.

Older faces elicited significantly faster reaction times ($F(1, 30.9) = 14.069$, $p < .001$; M = 656 ms, SE = 12.7) compared to younger faces (M = 678 ms, SE = 12.2). The response side effect did not reach significance ($F(1, 31.0) = 2.773$, $p = .105$), indicating no major difference in reaction times between the left-side (M = 671 ms, SE = 12.9) and right-side (M = 663 ms, SE = 11.8) responses. The interaction between age category and response side showed a significant reversed STEARC effect ($F(1, 6883.0) = 24.581$, $p < .001$, see Figure 3, panel A). By using the lsmeans R package, we performed Tukey's HSD tests for linear mixed-effects models (Lenth, 2016). Participants reacted significantly quicker ($z = 4.227$, $p < .0001$) to younger faces with the right key (M = 665 ms, SE = 12.1) than the left key (M = 691 ms, SE = 13.1). Although the participants were faster when pressing the left key for older faces (M = 652 ms, SE = 13.6) than the right key response (M = 661 ms, SE = 12.5), this difference was not statistically significant ($z = -1.562$, $p = .1183$).

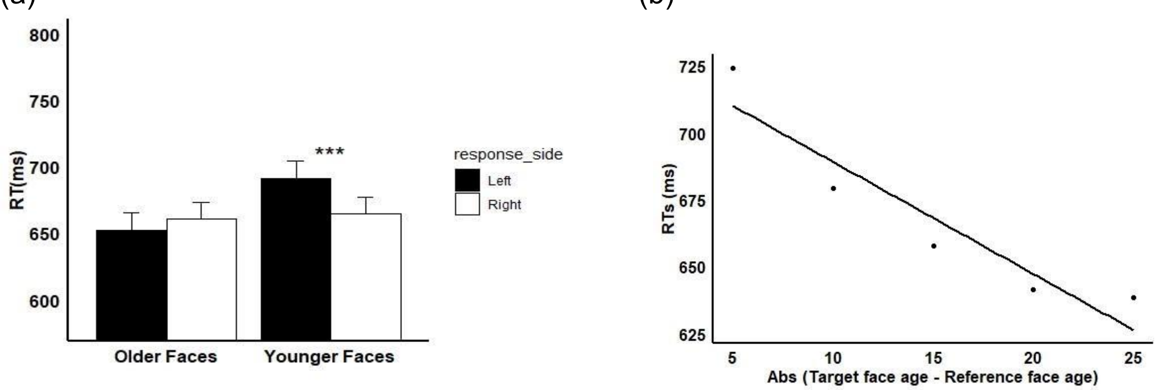
Table 1. *Descriptive Statistics for Response Time (ms) and Accuracy per condition*

		RT(ms)		accuracy	
		M	*SE*	*M*	*SE*
older	right	661	12.5	.930	.009
	left	652	13.6	.929	.009
younger	right	665	12.1	.961	.007
	left	691	13.1	.956	.008

We assessed accuracy by using increasingly complex mixed-effect logit models. The best-fitted model involved fixed effects for the response side and age category as well as their interaction. Also, the participant-specific random slopes for the effect of age category as a random effect were included. We found a significant age category effect which showed higher accuracy for younger faces (M = 0.958, SE = 0.008) than older faces (M = 0.930, SE = 0.007). On the other hand, the response side effect was not significant, b = −0.013, SE = 0.118, z = 0.113, p = .910, indicating that the accuracy is comparable for the responses on the right (M = 0.948, SE = 0.007) and the responses on the left (M = 0.944, SE = 0.007). In this analysis, the age category and response side interaction was not significant, b = 0.106, SE = 0.183, z = 0.580, p = .562.

Figure 3. *Reaction Times and Age Difference Effects in the Face Age Task*

(a) (b)



Note. Panel A displays the average reaction times (RTs) categorized by each experimental factor, with error bars representing the standard error of the mean. The three asterisks (***) indicate a statistically significant difference with $p<.001$. Panel B depicts the RTs in relation to the absolute difference between the age of the target face and the age of the reference face. The negative relationship observed indicates the presence of a distance effect.

Distance Effect

We wanted to see if the age difference between the reference face and the target face has impact on response time. With the linear mixed effect model, we examined this idea. The absolute age differences between the reference face and target face (5, 10, 15, 20, and 25 years) were included as fixed effects, and the intercept for the subject represented the random effect. The results showed a significant negative correlation between age difference and RTs ($b = -1.0321$, $SE = 0.1047$, $t(6935.112) = -9.853$, $p < .001$). This means that as the absolute age differences increase the RT decreases, and this finding suggests a distance effect (see Figure 3, panel B).

STEARC effect and EHI

Our study investigated the association between participants' Edinburgh Handedness Inventory (EHI) scores and the total STEARC effect index because there is a correlation between spatial concepts and handedness (Brunyé et al., 2012). The STEARC effect index was computed:

. Mi = [RTi(younger, right) - RTi(younger, left)] + [RTi(older, left) - RTi(older, right)]

Here, Mi represents the STEARC effect magnitude for each participant i. RTi(younger, right) and RTi(younger, left) denote the average response times when participants reacted to younger faces using the right-side and left-side keys, respectively. Similarly, RTi(older, left) and RTi(older, right) denote the average response times for older faces using the left-side and right-side keys, respectively. A highly positive Mi indicates a strong tendency to associate younger individuals with the left side and older individuals with the right side (Dalmaso & Vicovaro, 2019, 2021; Dalmaso et al., 2023). On the other hand, a highly negative Mi may indicate an inversed STEARC effect, suggesting faster responses when younger faces are on the right and older faces are on the left.

Our analysis showed no significant correlation between handedness and the STEARC effect index ($b = -0.019$, $SEb = 0.078$, $t(30) = -0.254$, $p = .801$).

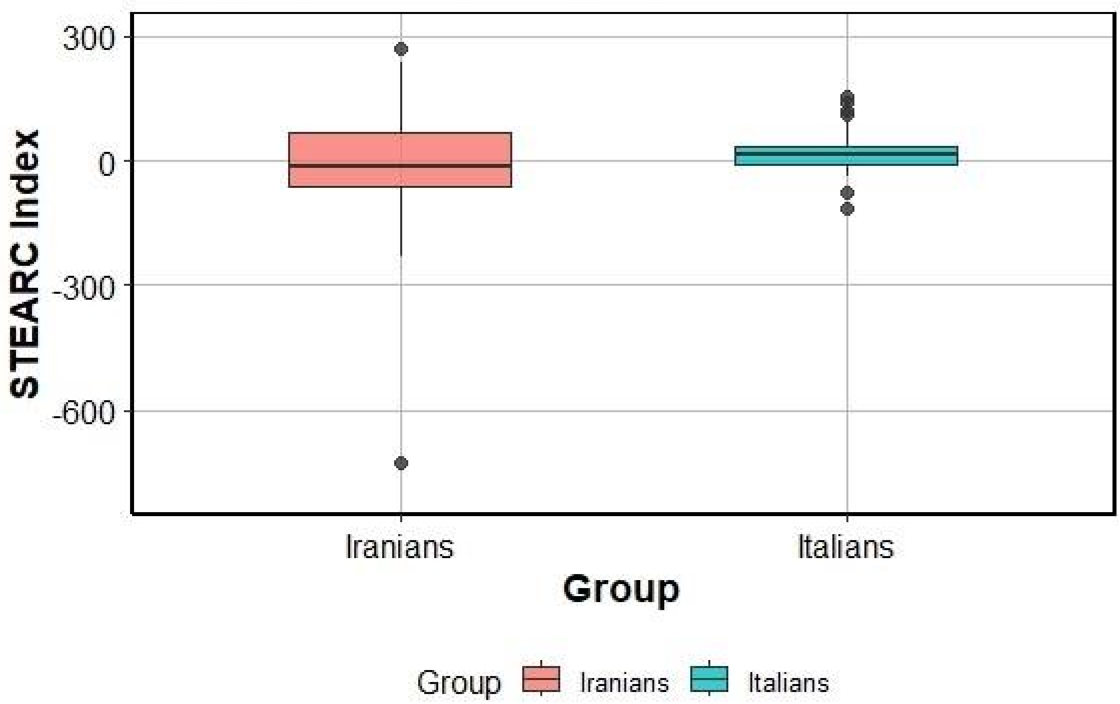
STEARC effect and the Temporal Focus Index

The mean Temporal Focus Index of the Iranian participants was 0.11, with 87.5% of the participants being categorized as future focused and 12.5% as past focused. Regarding the correlation analysis between the Temporal Focus Index and the overall STEARC effect index, the findings revealed a no significant correlation ($b = 1.626$, $SE = 2.955$, $t(30) = 0.586$, $p = .586$). This indicates that variations in participants' temporal focus, as quantified by the TF Index, do not predict differences in the overall STEARC effect index.

Comparing the STEARC effect index between Iranian and Italian

The comparison of the STEARC effect index between Iranian and Italian populations revealed distinct patterns in spatial-temporal associations. Italians displayed a mean STEARC index of 22.21, indicating quicker responses to older faces on the right and younger faces on the left. Conversely, Iranians exhibited a mean index of -35.44, reflecting an inversed pattern with faster responses to older faces on the left and younger faces on the right (see Figure 4). Using a one-tailed Welch's two-sample t-test, we found a marginally significant difference where the Iranian indices tended to be lower than the Italian indices ($t(35.629) = -1.4234$, $p = 0.0816$).

Figure 4. *Comparisons of STEARC effect indices between Iranians and Italians*



Note. Each point corresponds to outliers in the data. The boxplot visually represents the data distribution with a box that spans from the first quartile (Q1) to the third quartile (Q3), known as the interquartile range (IQR). Inside the box, a line indicates the median value of the dataset.

The Temporal Diagram Task

In the Temporal Diagram Task (TDT), 59.375% of the Iranian participants placed future events on the left and past events on the right, while 40.625% placed future events on the right and past events on the left. We conducted a one-sample sign test to evaluate whether the proportion of participants who "placed future events on the left and past events on the right" significantly differed from 0.5. The null hypothesis (*H0*) stated that the proportion of participants placing future events on the left and past events on the right is 0.5. Out of 32 participants, 19 followed this placement, while 13 did not. The test yielded a *p* value of 0.3771, which indicates that we failed to reject the null hypothesis. Thus, our findings do not provide evidence to conclude that the proportion of participants who placed future events on the left and past events on the right differs from 0.5. It is important to note that despite the lack of statistical significance, the direction of our results aligns with the STEARC effect. However, the small sample size in our study (n = 32) may have limited our ability to detect a significant effect. Further research with a larger sample size is warranted.

Discussion

This thesis is based on the study by Dalmaso et al. (2023), which examined whether face age could induce a STEARC effect across the lateral, sagittal, and vertical spatial axes. They observed a STEARC effect on each axis. Based on previous findings with other types of stimuli, we hypothesized that the spatial representation of face age on the lateral axis would be linked to the direction of the orthography mainly used by the participants (Fuhrman & Boroditsky, 2010; Ouellet et al., 2010; Pitt & Casasanto, 2020; Tversky et al., 1991). Consequently, we decided to investigate this effect in a population with opposite reading and writing habits as compared to Italian (i.e., Iranian), focusing on the lateral axis. We used both implicit and explicit measures, including the Face age task and Temporal diagram task, to determine if reading and writing directions are related to the STEARC effect.

The results provided evidence supporting the hypothesis that cultural and/or linguistic factors are linked to the STEARC effect. Conversely to Italian participants in Dalmasso et al.'s (2003) study, Iranian participants, who use a right-to-left orthographic system, showed a left-future/right-past congruency effect, it is to say an inversed STEARC effect. This finding aligns with the hypothesis that the direction of the orthographic system might influence spatial-temporal associations. Our results are consistent with previous research by (Fuhrman & Boroditsky, 2010; Ouellet et al., 2010; Pitt & Casasanto, 2020; Tversky et al., 1991), who found similar opposite effects between left-to-right versus right-to-left readers on the lateral representation of time. This study also diverges from prior research (Rashidi-Ranjbar et al., 2014) that reported non-significant spatial-numeric associations in mixed reading cultures, suggesting that the nature of the stimuli (ageing faces vs. numbers) might influence spatial mappings.

A distance effect was also observed in our study with Iranian participants. We observed that reaction times decreased linearly as the age difference between the target and the reference faces grew. This finding aligns with that reported by Dalmaso and Vicovaro (2021) and Dalmaso et al. (2023). It indicates that greater age differences are easier to distinguish than similar age differences, a finding in line with the distance effect theory proposed by Moyer and Landauer (1967). It also means that the participants order the different ages consecutively on their mental timeline (see Santiago et al., 2010, for a similar effect with temporal sequences). Since this effect was consistent across both the Iranian and the previously studied Italian samples, it indicates that, despite the differences in the spatio-temporal mapping of age, the consecutive order used to map age stimuli in both cultures operates similarly.

The use of the Temporal Focus Questionnaire further enriched our understanding of how cultural factors influence temporal orientation. According to the Temporal Focus Hypothesis (TFH), cultural or subcultural factors can bias individuals toward past or future orientations, which in turn can influence the spatial mappings of time (de la Fuente et al., 2014), but this TFH has been studied only the sagittal axis (e.g., Callizo-Romero et al., 2020). It is first interesting to note that most of the Iranians participants were future oriented (87.5%). Nevertheless, no significant correlation was found between the temporal focus index and the overall STEARC effect index, indicating that variations in participants' temporal focus did not predict differences in their spatial-temporal associations. This finding points to, contrary to the mapping of time on the sagittal axis, an absence of an influence of the temporal focus on the lateral mapping of time.

Our exploratory examination with the Temporal Diagram Task, aimed at assessing explicit spatial representations of time by asking the participants to arrange past and future events along a horizontal axis, offered additional insights. While nearly 60% of the Iranian population placed future events on the left and past events on the right, we cannot conclude at the moment that the explicit representation of time follows the implicit representation. More research is needed with more participants. Such research will add to the knowledge of the lateral and explicit representation of time, which has already been demonstrated on the sagittal axis (e.g., Callizo-Romero et al. 2020, de la Fuente et al., 2014).

Future studies could complement this research to investigate mapping of age faces in the Iranian population, like its mapping on other dimensions, such as the sagittal and/or the vertical axes. Additionally, replicating this study with cultures with mixed reading and writing habits, like Israelis, or cultures with more strict right-to-left reading and writing habits, such as Palestinians (Shaki et al. 2009), could provide further insights to confirm the influence of reading and writing direction on the spatio-temporal associations across different cultural contexts.

In conclusion, our study contributes to understanding how cultural and linguistic factors are related to the spatio-temporal associations. Italians, with their left-to-right reading direction, and Iranians, with their mixed reading habits, displayed opposite spatio-temporal mappings. These results corroborate previous research on the mental timeline (Boroditsky et al., 2011; Dalmaso & Vicovaro, 2021; Dalmaso et al., 2023) and highlight how culture and language can influence cognitive processes. Notably, the results for Iranians are novel. No prior research has demonstrated a bias in the STEARC effect for Iranians with the social stimuli of ageing faces. Furthermore, the consistent observation of the distance effect across both cultures suggests a universal cognitive mechanism in age perception. Overall, this research deepens our understanding of the interplay between culture, language, and cognition, offering valuable insights into how different cultural backgrounds can shape our perception of time and space.

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