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Two Cultural Processing Asymmetries Drive Spatial Attention

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Abstract

Cultural routines, such as reading and writing direction (script direction), channel attention orientation. Depending on one's native language habit, attention is biased from left-to-right (LR) or from right-to-left (RL). Here, we further document this bias, as it interacts with the spatial directionality that grounds time concepts. We used a spatial cueing task to test whether script direction and the grounding of time in Portuguese (LR, Exp. 1) and Arabic (RL, Exp. 2) shape visuomotor performance in target discrimination. Temporal words (e.g., tomorrow, yesterday) were presented as cues in two modalities: visual (Exp. 1–2) and auditory (Exp. 1). Gaze movement (Exp. 1) and speed of discrimination decisions (Exp. 1–2) of targets presented to the left or right sides of the screen were assessed. As predicted, the interaction between target location and time concepts was significant across both modalities and linguistic communities. Additionally, LR participants detected the target on the right side of the screen faster after a future word than the target on the left side of the screen after a past word cue. In contrast, RL participants detected the target on the left side of the screen faster when the cue word was a future word than the target on the right side of the screen cued by a past word. In both modalities, the initial eye-gaze movement (Exp. 1) was responsive to the cue's time referent, further confirming that time orients attention. An additional bias was observed for the first fixation onset, which landed earlier on the target set that matched habitualized spatial routines. We conclude that scanning regularities are shaped by writing habits and bodily grounded categorical features.

Keywords: Spatial bias; Language script; Visual attention; Time; Eye-tracking

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1. Introduction

Different features of language drive visuospatial attention in different spatial dimensions. For instance, word cues such as *up*, *down*, *left*, and *right* drive spatial attention consistent with their semantic meaning driving stimuli appearing in the indicated locations to be processed faster (e.g., Cristescu, Devlin, & Nobre, 2006; Ho & Spence, 2005; Hommel, Pratt, Colzato, & Godijn, 2001). Reading and writing practices constitute another organizing convention contributing to the systematicity of visuospatial attention (Spalek & Hammad, 2005; Suitner & Maass, 2016). In languages like English, reading and writing unfold from left to right. In contrast, in languages such as Arabic or Hebrew, these processes unfold from right to left. Such cultural scanning norms determine implicitly a preferential eye trajectory that generalizes to the scanning of visual objects. For instance, they shape the visual exploration of artwork (Chokron & De Agostini, 2000), agentic perceptions from faces (Mendonça, Garrido, & Semin, 2020b), or scanning preferences of soccer goals and action film clips (Maass, Pagani, & Berta, 2007).

Additionally, the abstract category of time (e.g., today, yesterday) is grounded on a left-to-right (LR) or left-to-right (RL) horizontal timeline as a function of the type of linguistic community. Examples would be the English or Hebrew linguistic communities (Fuhrman & Boroditsky, 2010). These two spatial orientations, one being reading and writing direction and the other the grounding of abstract time concepts constituted the stimulus material for the two studies reported here. We used two contrasting cultures. One has a habitualized LR writing and reading direction and the other a habitualized RL writing and reading tradition.

The studies had two attention and gaze movement driving factors predicted to shape detection latencies on a modified spatial cueing paradigm. Critically, the cues used in this paradigm are instances of the abstract category time (“yesterday,” “tomorrow”). This allows us to test the joint influence of two sources of bias on attention and gaze movement and detection latencies, namely:

1. The spatial *grounding of time concepts* (Casasanto & Boroditsky, 2008; Santiago, Lupiáñez, Pérez, & Funes, 2007; Torralbo, Santiago, & Lupiáñez, 2006; Weger & Pratt, 2008) and
2. cultural habits of reading and writing known to drive attention consistent with the habitual movement direction, namely, either LR (e.g., English) or RL (e.g., Arabic) *script direction* (Bettinsoli, Maass, & Suitner, 2019; Maass & Russo, 2003; Mendonça, Garrido, & Semin, 2020a).

1.1. Background and rationale

The first factor we discuss is the spatial grounding of time. Time is spatially grounded. For instance, when reading and writing, we leave prior information behind, establishing a natural movement–space correlation that maps time in a script-consistent pattern (Casasanto, 2014). Time has been shown to activate spatial associations along the horizontal continuum (Blom & Semin, 2013; Boroditsky, 2011; Lakens, Semin, & Garrido, 2011). Temporal events are organized on an LR or RL horizontal timeline depending on whether samples come from

English or Hebrew linguistic communities (Fuhrman & Boroditsky, 2010). Past terminology is anchored where writing typically begins: on the left for LR speakers and on the right for RL speakers. Consequently, future-related terms are anchored on the opposite end of the horizontal continuum: on the right for LR speakers and on the left for RL speakers (Ouellet, Santiago, Israeli, & Gabay, 2010; Torralbo et al., 2006).

The second factor concerns the influence of script direction on spatial asymmetries in the perception of agency and related categories (e.g., time). Different explanations have been advanced for these asymmetries. Biological ones argue that right hemispheric dominance drives the leftward asymmetrical anchoring of visual space in visuospatial tasks (Brooks, Sala, & Darling, 2014). However, other research shows that the leftward attentional bias is shaped by written script, reading direction, as well as cultural experience (Kazandjian & Chokron, 2008; Rosenich, Shaki, & Loetscher, 2020). The preference for the left hemispace can be changed to the opposite direction when tasks are performed by readers from RL-speaking countries (Afsari, Ossandón, & König, 2016; Smith & Elias, 2013). Also, bidirectional readers show negligible lateralization in task performance (Rinaldi, di Luca, Henik, & Girelli, 2014). This indicates that reading direction may, at the very least, mitigate the predisposition to over-attend to the left side of space. No doubt, the nature of the task at hand, as well as the instructions given to participants, can constrain visual performance. For example, in addressing exploratory biases during the initial exploration of complex visual stimuli, Ossandón, Onat, and König (2014) reported a preference for initial saccades to the left space (in LR readers) in a task where participants were asked to freely explore a set of images.

This is very different from a setup where, prior to target onset, the participants' gaze is mandatorily anchored at the center of the screen, and stimuli are presented bilaterally. In such a setup, visual attention is expected to progress from the starting point in line with the reading direction (i.e., right for LR readers and left for RL readers; Mendonça et al., 2020a, 2021). In this case, attention would not regress to the habitual starting point of reading/writing. Once attention is set in motion, it would be costly and counterproductive to go against the habitual reading/writing trajectory and return to its initial location (attentional momentum; Pratt, Spalek, & Bradshaw, 1999). Indeed, when attention flows in a direction that is script-coherent, task performance is enhanced because one can anticipate the occurrence of future information (Pratt et al., 1999; Spalek & Hammad, 2004). In sum, when people are provided with a specific instruction regarding what to do (e.g., find the target), and a prime drives attention toward a specific location, attention is goal-driven and will progress according to (a) the grounding of the cue (in our case, time-related words) and (b) the direction of the language script.

Consider a stimulus presentation in which two five-letter strings (one of which contains the target letter) are presented simultaneously to the left and right of the screen and preceded by the presentation of a time-related central cue (e.g., yesterday, tomorrow) that anchors the starting position of the gaze movement. If the script direction bias is correct, then one would expect attention to progress from the center in a script-coherent direction (rightward for LR speakers and leftward for RL speakers). Therefore, cue words would speed up detection times and facilitate gaze movements if: (a) the cue word implies a reference to the side of the screen that is consistent with script direction (e.g., tomorrow; right side of the screen advantage for LR speakers and left side of the screen advantage for RL speakers) and (b) the target letter is embedded in the letter string located on the side of the screen congruent with the indication of the word cue (right string for LR speakers and left string for RL speakers). The bias introduced by script direction is that the same detection speed and gaze advantage will not be to the same extent for the congruent conditions (e.g., detection of a target letter presented to the left after the cue word "yesterday" and presented to the right after the word cue "tomorrow" for LR speakers). Rather, it will be differentiated in favor of the cue–target pairs that reflect the habitual script direction (target letter on the right after "tomorrow"). In the special combination of words, we have two biases operating simultaneously. The first is words as language, activating habitual script direction, and the second is time concepts anchored on the horizontal past–future dimension. Both induce moving in the same direction. By choosing cues that potentially bring together both the influence of script direction and of an abstract category (time), we introduce a critical experimental condition. In the case of an LR culture, future referent cues and targets on the right side of the screen should be processed significantly faster than past referent cues and targets on the left side of the screen rather than being processed symmetrically. This asymmetric processing should be reversed in the case of RL cultures.

Additionally, presenting cue words in visual and auditory modalities would provide converging evidence of the process driving target detection and the function of cue words. If the pattern of speed and gaze outcomes in both modalities converges then one would infer that spatial bias is independent of the motor processes activated by reading.

Previous cross-modal cueing experiments (i.e., where cue and target pertain to different modalities) typically report a facilitation in performance when the cue and target sensory modalities coincide in their directional content (Dufour, 1999; Spence & Driver, 1994, 1997). Moreover, visual attention is reflexively drawn to auditory-conveyed locations. Kean and Crawford (2008) manipulated the expectancies of the auditory cue informing visual target location (80%, 50%, and 20% probability) and observed significantly better behavioral and eye-movement performance for the cued side of the screen even when the target location was against probabilities. This processing advantage indicates that auditory information is unavoidable even when people are aware that the target is more likely to appear elsewhere. The structural link between vision and audition in attention orienting is likely biological and adaptive (Spence & Driver, 1997), as humans benefit from integrated and sensory-rich inspections of their vicinities. However, many perceptual phenomena are dominated by the visual modality over other sensory inputs (Spence, Parise, & Chen, 2011), making the relationship between vision and audition in cueing tasks rather complex.

On the other hand, the structuring of time in space has consistently been reported in distinct tasks, not only in the visual but in the auditory modality as well (Lakens et al., 2011; Ouellet et al., 2010). However, to the best of our knowledge, prior research on the spatial mapping of time has addressed the impact of visual and auditory modalities in isolation. In this research, we shall be able to examine the relative contribution of each modality as well as their combined effect in inducing biased attention shifts. This will allow us to rule out spatial biases as a product of the directional act of reading the word prime. Newly, if reading and hearing the word cue yield similar effects, then we will be able to put together a solid research package showing that the mapping of time (a) is not modality dependent, (b) is above the relative LR spatial positioning of the effectors, and (c) is shaped by reading and writing scanning habits and is by no means universal.

1.2. Overview of the present research

The present studies were designed to examine how two habituated cultural forces facilitate the detection of targets presented on the left and right sides of the screen. As we suggested, the first is cues as words activating script direction (Román, Flumini, Lizano, Escobar, & Santiago, 2015), and the second is cues as time concepts anchored on the horizontal past-future dimension (Santiago et al., 2007). To this end, we used a modified spatial cueing task (Mendonça et al., 2020a). In contrast to the typical balanced congruency effects, we predicted an asymmetric performance favoring congruent cue–target combinations that match participants' script direction. As the initial point of gaze movement is anchored in the center of the screen, attention was expected to progress in line with cultural reading and writing habits (Suitner & Maass, 2016) in addition to the horizontal grounding of the time cue. Thus, future words have a double processing advantage as cues. They facilitate target detection on the right side of the screen for LR speakers (Exp. 1) and on the left side of the screen for RL speakers (Exp. 2). This facilitation is expected to be revealed primarily by detection speed (Exp. 1 and 2) and the overall trajectory revealed by gaze movement (Exp. 1). We expected detection speed effects to be mirrored in the two languages (RL and LR). The asymmetry favoring the right or the left is, therefore, a product of the match between habitual script direction and horizontal semantic bias of the time referent word cue.

2. Experiment 1

The first experiment examined the detection speed of the target as a function of script direction (LR) and time-related words (cues). We predicted overall detection facilitation for congruent (vs. incongruent) cue—target conditions, that is, shorter response times when time-related cue word connotation is consistent with the target letter location. Moreover, we predicted that these specific effects to be asymmetric between congruent cue–target pairs. In other words, the joint influence of L-R script direction bias in L-R languages together with future-related cue words should yield shorter response times when the target location is on the right side of the screen relative to the response times of congruent past-related words and the target letter is on the left side of the screen. Neutral words, which should not induce a systematic horizontal movement, are not expected to produce differences in performance across both sides of the screen.

Moreover, we expected the initial gaze movement to be faster to the right area of interest (AOI) as a function of both script direction and future-related cues. Finally, we expected a similar pattern of results across visual and auditory modalities.

2.1. Method

2.1.1. Participants

Fifty-nine undergraduate students (40 women and 19 men, $M_{age} = 20.36$, $SD_{age} = 1.81$; 12 self-reported left-handers) were recruited and compensated with course credit. The sample size was determined a priori using Bias- and Uncertainty-Corrected Sample Size R package used for implementing the method (Anderson, Kelley, & Maxwell, 2017), adjusting sample size effects for uncertainty and publication bias correction (desirable level of assurance = 0.90; statistical power = 0.80) based on the effect size proposed for temporal priming effects (von Sobbe, Scheifele, Maienborn, & Ulrich, 2019). Participants were screened for normal or corrected-to-normal visual acuity and had no hearing problems. They were self-declared native Portuguese speakers. All participants gave written informed consent for their participation. Both experiments were performed according to the ethical guidelines in place and approved by the Ethics Committee of the host institution.

2.1.2. Cues

Forty-eight time-related words were selected from a list of Spanish words used in similar tasks (Ouellet et al., 2010; Torralbo et al., 2006). The words reflected a temporal continuum, that is, we selected a range of words pertaining to the distant past and future as well as to the immediate past and future. Translation of words to Portuguese yielded 16 past-related words (e.g., “ontem”–“yesterday”), 16 future-related words (e.g., “amanhã”–“tomorrow”), and 16 words that were time-related but neutral in content (e.g., “dia”–“day”; see Appendix 1 for the entire list). In each past and future-related set of 16 words, there were eight verbs inflected in either the past or future tense and eight temporal adverbs. In a previous validation study of the cue words, we presented the word list in a random order to Portuguese participants ($n = 99$). Participants were asked to move a sliding bar along a horizontal line to a position they thought best represented the time-related word (0 = *distant past*; 100 = *distant future*). The words were grouped according to their mean ratings and semantic meaning ($F(2, 47) = 235.347$, $p < .001$; past-oriented: $M = 22.10$, $SD = 7.71$; neutral: $M = 53.04$, $SD = 2.36$: future-oriented: $M = 77.60$, $SD = 9.63$; ps $< .001$ between groups). Eight additional words were used for the practice block. Words were then converted to sound files using a text-to-speech application. Word duration did not differ across the time category of the words, $F(2, 47) = 0.440$, $p = .647$ ($M = 992$, $SD = 171.02$). Throughout the experiment, each word was presented twice visually and twice auditorily.

2.1.3. Targets

The target stimuli consisted of two five-letter strings. Only one string contained one of the two possible target letters—*q* or *p*. The remaining letters in the strings were distractors (four letters and the target letter on one side of the screen; five letters on the other). The two strings subtended 4.77° visual angle and were simultaneously presented in the near peripheral visual field at the left and right sides of the screen midpoint (± 13.31° eccentricity). Therefore, it was not possible to process the target letter strings unless eye movements were made. Target and filler letters were kept constant across the experiment and were varied randomly within the five possible letter positions in the set. The task entailed a discrimination decision between two possible targets (*p* or *q* on the gamepad) and not a spatial decision regarding the side of the screen the target letter appeared; hence (1) circumventing a systematic overlap between response code and target letter location, and (2) preventing participants from inferring target location by merely gazing at one side of the screen. This discrimination setup ensures that performance cannot be accounted for by the target's spatial positioning (because the target's location on the gamepad does not necessarily match its lateral positioning on the screen).

2.1.4. Apparatus and Display

The task was programmed in Experiment Builder (Version 1.10.1630, SR Research, 2016). The stimuli were displayed on an Asus VX238H 23'' Full HD LED monitor (1920 × 1080) driven by a Dell OptiPlex 755 with a refresh rate of 60 Hz. Eye movements were calibrated and recorded from the dominant eye with a 1000 Hz Eyelink 1000 plus. A 5-point calibration procedure was performed, resulting in a reported interval of 0.25–0.5° average accuracy for all points. Errors higher than 1° at any point led to a repetition in the calibration. A headrest was used to restrict participants' head movements and control the viewing distance to the screen at 60 cm. The task was presented against a medium gray background. Manual responses were collected using the keys marked as *q* and *p* on a standard gamepad. Auditory stimuli were presented via headphones.

2.1.5. Procedure

The task was administrated in single sessions at the university's laboratory. Participants were asked to put on headphones and read the instructions. They were instructed to press the respective response key on the gamepad as soon as they detected the target letter embedded in one of the two five-letter strings. They were also informed that the words were not informative of the target location.

Each trial began with a 1000 ms drift check fixation (0.3 × 0.3°), which was gaze-contingent, therefore anchoring the participants' initial gaze movement at the center of the screen. The drift check was followed by the presentation of the word cue, either visually at the center of the screen for 1000 ms or auditorily via headphones for the duration of the sound file. Auditory stimuli were presented binaurally and equally loud to both auditory channels. During the auditory stimuli presentation, a gaze-contingent cross was presented in the center of the blank screen, ensuring participants' starting point of visual exploration prior to target onset. A blank screen followed the cue and lasted 150 ms. The two five-letter strings were then simultaneously presented to the left and right sides of the screen until participants responded or when 1000 ms had elapsed. After responding, participants received a feedback message informing them about the accuracy of their response or whether they were too slow (Fig. 1). There were 192 trials in total, divided into two blocks, plus 16 practice trials. The number of congruent and incongruent trials was kept constant across the experiment; thus, word cues were uninformative of the target location. All factors (modality, word category, and target location) were equally likely and presented in a counterbalanced order within a block. Participants took a 5-min break between blocks, followed by a recalibration. The experiment took approximately 30 min to complete.

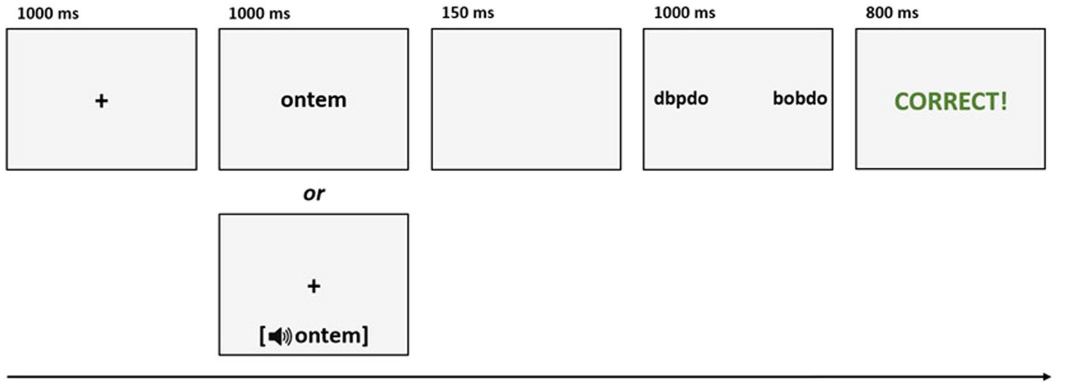

Fig. 1. Overview of the experimental procedure in Experiment 1.

The reason for selecting the 1000 ms response window was two-fold: (1) we wished to record participants' automatic attention shifts as a response to the word cues. A short response window (vs. a longer, or unlimited response window) prevents the development of scanning strategies across trials, which would likely undermine the effectiveness of the word prime; and (2) prior research employing a similar paradigm with bilateral targets has tested three response intervals of 700, 1000, and 1300 ms (Mendonça et al., 2020a). Average response times for the 1000 ms interval were around 600 ms, therefore we expected most of our responses to fall within the 1000 ms interval. Additionally, as this task is demanding and carries a high perceptual load due to the large number of target items to be processed, we considered the 1000 ms window to be appropriate to ensure an optimal trade-off between correct and missing responses.

2.2. *Results*

2.2.1. *Preliminary analysis*

Correct detections under 100 ms were excluded from the analysis to ensure that response times were not influenced by anticipatory responses (0.9%). Missing responses (trials where the time for responding elapsed) corresponded to roughly 31% of the total number of trials across participants.[1]

2.2.2. *Reaction time*

To test our hypothesis regarding the facilitation of detection in the case of congruent (vs. incongruent) cue–target conditions and an asymmetric performance favoring future-related words and targets located on the right side of space, we performed a linear mixed model (LMM) analysis. This analysis allowed us to control for the variance due to word stimuli (word ID), the number of characters in the word (word length), and participants' individual differences (participant ID). We observed no severe violation of the homoscedasticity or normality assumptions in a visual inspection of the residual plots. The distribution of residuals does not compromise the use of an LMM given that the violation of the normality

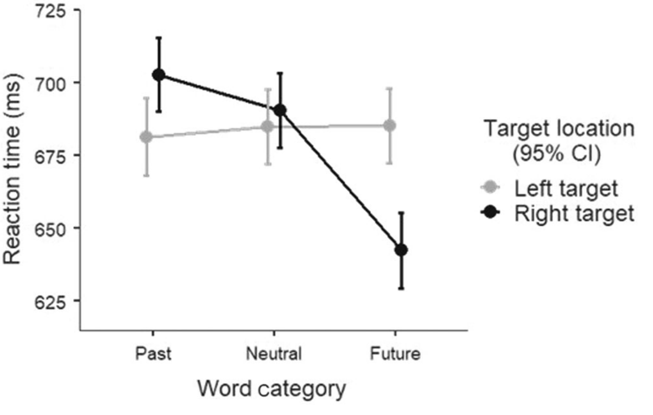

Fig. 2. Mean reaction time (in milliseconds) as a function of the word category and the target letter location. Error bars represent 95% confidence intervals.

assumption poses a problem only when samples sizes are small ($n < 30$), and alternative procedures (e.g., data transformation) have been pointed out as relatively more error-prone (Knief & Forstmeier, 2021). The LMM was performed in jamovi software (version 1.2) with the GAMLj module.

The LMM included word ID, word length, and participant ID as random intercepts and the model's fixed effects were prime modality (visual vs. auditory), word category (past vs. neutral vs. future), target location (left vs. right), and their second and third-order interactions. Any parameter with a variance greater than 0 was left as random (Littell, Pendergast, & Natarajan, 2000). Word length presented a variance of 0 and was removed from the model. The model was estimated using restricted maximum likelihood, with a Satterthwaite approximation of the degrees of freedom.

The LMM analysis ($R^2_{marginal} = .02$; $R^2_{conditional} = .08$) revealed main effects of prime modality, F (1, 5790) = 21.83, $p < .001$, and word category, F (2, 41.4) = 20.97, $p < .001$. Post hoc comparisons using Holm correction revealed that targets were detected significantly faster following visual ($M = 673$, $SE = 5.07$) relative to auditory word primes ($M = 690$, $SE = 5.05$, $p < .001$). Future-related words gave rise to shorter detection latencies ($M = 664$, $SE = 5.47$) than neutral ($M = 688$, $SE = 5.48$, $p < .001$) and past-related words ($M = 693$, $SE = 5.45$, $p < .001$). Past and neutral word cues did not produce significantly different response times ($p = .312$). The expected word category × target location interaction was significant, F (2, 41.4) = 24.48, $p < .001$ (Fig. 2), indicating that congruent (vs. incongruent) conditions facilitate detection. Targets on the left side of the screen were detected faster when past cue words were presented ($M = 682$, $SE = 6.46$) than targets on the right side of the screen ($M = 703$, $SE = 6.35$, $p = .044$). Conversely, targets on the right side of the screen benefited from future word cue presentation ($M = 642$, $SE = 6.45$) relative to targets on the left side of the screen ($M = 685$, $SE = 6.42$, $p < .001$). Neutral words did not produce significant differences on detection of left ($M = 685$, $SE = 6.45$) and right targets ($M = 690$, $SE = 6.46$, $p = 1.000$) and hence did not prime any particular directionality.

Finally, to investigate the asymmetry between the congruent conditions reported above and favoring the LR, script-coherent cue–target pairs, we report the post hoc comparison between past word—left target and future word—right target conditions. Results indicate unequivocal facilitation for congruent cue–target pairs that referred to the right (vs. left) side of space, $t\,(43.9) = 5.87, p < .001$.

The remaining interactions were statistically not significant (ps $> .06$). The fact that the third-order interaction did not reach statistical significance ($p = .117$) suggests that the congruency effect occurs irrespective of the sensory modality of presentation. As we hypothesized, presenting time-related words visually or auditorily did not affect the interaction between word category and target location on response times. This result is in line with previous research (Lakens et al., 2011) and suggests that the spatial representation of time converges across visual and auditory perception. Nevertheless, this result should be interpreted with caution given that we did observe a significant main effect of visual over auditory word presentation, with target discrimination benefiting from the visual format to a greater extent. It appears that, at the first instance, the visual modality takes precedence and contributes to shorter detection latencies. However, the privileged processing of the visual word primes seems to be overridden when the temporal category of the word and the location of the target are considered.

If thinking about abstract concepts implying movement involves embodied simulations of the way we typically execute motion, then actions in right-handed and left-handed individuals could have different cognitive representations and lead to asymmetrical outputs (Casasanto, 2009). Previous studies have investigated whether genetic predispositions, particularly a higher right-hand skill in performing motor tasks, could account for lateral preferences (Faghihi, Garcia, & Vaid, 2019; Nachson, Argaman, & Luria, 1999; Rolke, Ruiz Fernández, Lopez, & Seibold, 2014). An argument could be made that the rightward asymmetry observed is due to participants interacting with their environment more fluently with their dominant hand (typically the right hand; Corballis & Beale, 1976), instead of being due to the exposure to a particular writing system.

To rule out handedness as driving the cueing effects obtained, particularly if it was the overlap between the right-handedness of most participants with the right target location that was driving the rightward facilitation effects, we examined average response times that occurred when participants used the *q* key ($M = 683.56$, $SE = 40.20$; pressed with the left index finger) and the *p* key ($M = 679.30$, $SE = 37.50$; pressed with the right index finger). No difference in response time was observed when left and right hands were used to respond, $t\,(58) = 1.072$, $p = .288$.

2.2.3. Eye-tracking data

We flagged and excluded trials in which the observer's gaze at fixation could not be verified to be within 1° of visual angle or for a minimum of 1000 ms (1.3% across all trials fixations). Fixations under 80 ms were excluded (4.90%), as were trials in which the tracker lost eye position (1.1%). We defined two rectangular AOIs, which correspond to the target letter strings located on the left and right sides of the screen. Eye gaze measures were recorded from target onset.

2.2.4. The direction of first saccade

To examine initial gaze movement and confirm that the time-related words did guide attention, we examined the proportion of the first saccade in each trial (i.e., the oculomotor response to the prime) made to the left and right side of the screen, as a function of the prime modality and word category. It is important to emphasize that participants' initial gaze movement was anchored in the center of the screen prior to target onset. Since binary data do not follow a normal distribution, we opted for a test based on the binomial distribution to model our data.

We analyzed the first saccade direction in a logistic mixed-effects model to further control for the variance introduced by the word stimuli (word ID), the number of characters in the word (word length), and the participants' individual differences (participant ID). The model predicted the probability of the direction of the first saccade (0 = saccade to the left; 1 = saccade to the right) in terms of log odds. Prime modality (visual vs. auditory) and word category (past vs. neutral vs. future) and their interaction were entered as fixed effects. Target letter location was not included as a factor in this analysis because, as hypothesized, we were interested in testing the first ocular response to the prime and attesting whether the temporal words were capable of priming attention. Intercepts for word ID, word length, and participant ID were included as random effects. Word ID and word length, as well as their intercepts, were removed from the model because their variance was 0, and hence these variables did not contribute to the model.

The model ($R^2_{marginal} = .02$; $R^2_{conditional} = .22$) showed that the first saccade in each trial did not follow an arbitrary distribution across both sides of the screen but a preferential spatial scanning. First saccades were shaped by word category, $\chi^2 = 165.29$, df = 2, $p < .001$. Taking the past-related words as the reference category, we observed a positive regression slope for future-related words, which suggests that these words are more likely to trigger saccades to the right space, $\beta = 0.59$, $SE = 0.05$, $z = 11.65$, $p < .001$, by a factor of 1.8 (CI [1.636, 1.997]). Neutral words also produced a positive regression slope, that is, they are also more likely to induce rightward saccades than the reference category (past words) although not significantly so, $\beta = 0.05$, $SE = 0.05$, $z = 1.08$, $p = .279$. Further, an interaction between prime modality and word category was observed, $\chi^2 = 16.804$, df = 2, $p < .001$. We noted a significant negative regression slope for the comparison between auditory and visual primes and future- and past-related words, $\beta = -0.40$, $SE = 0.10$, $z = -3.98$, $p < .001$. These results indicate that visual cues are more effective than auditory cues in driving rightward saccades following future words. The detailed parameter estimates can be found in Table 1.

Post hoc comparisons using the Holm correction confirmed that past-related words have a lower probability (.45) of generating initial saccades to the right than future words (0.60; $z = -11.65$, $p < .001$). Likewise, neutral words (0.46) are also significantly less likely to trigger rightward initial saccades than future words ($z = -10.59$, $p < .001$). Like what we have already observed in the reaction time measure, neutral words gave rise to a comparable initial gaze distribution to the one observed for past-related words ($z = -1.08$, $p = .279$; Fig. 3). As for the significant interaction, auditory past words (0.47) were less likely to evoke right saccades than auditory future words (0.56; $z = -5.48$, $p < .001$) just like visual past words (0.43) are less likely to trigger right saccades than visual future words (0.63; $z = -10.99$,

Table 1
Fixed effects parameter estimates for the logistic mixed model predicting the proportion of the direction of the first saccade by prime modality and word category

	Effect	*B*	*exp(B)*	95% Confidence Interval *Lower*	95% Confidence Interval *Upper*	*z*
Prime Modality	*Auditory − Visual*	−0.03923	0.962	0.887	1.042	−0.9510
Word Category	*Neutral − Past*	0.05453	1.056	0.957	1.166	1.0825
Word Category	*Future − Past*	0.59190***	1.807	1.636	1.997	11.6531
Prime Modality × Word Category	*Auditory − Visual × Neutral − Past*	−0.11221	0.894	0.734	1.089	−1.1139
Prime Modality × Word Category	*Auditory − Visual × Future − Past*	−0.40248***	0.669	0.548	0.815	−0.3.9753

Note. Past is the reference category for the word category variable.
***$p < .001$.

$p < .001$). These findings confirm that, across modalities, both past and future words did deploy automatic attention in a direction that is consistent with their temporal connotation.

2.2.5. First fixation onset

After confirming that time-related words induce the expected orientation of attention, we investigated if there is, in fact, a LR bias of attention. To this end, we tested if the first fixation onset, that is, the time in the trial the first fixation landed on the left and right AOIs, was biased across modalities by time words pertaining to the right. Again, target location was left out of this analysis because we aimed to show that the initial gaze movement and the resulting first fixation was biased toward the right region of interest, irrespective of whether

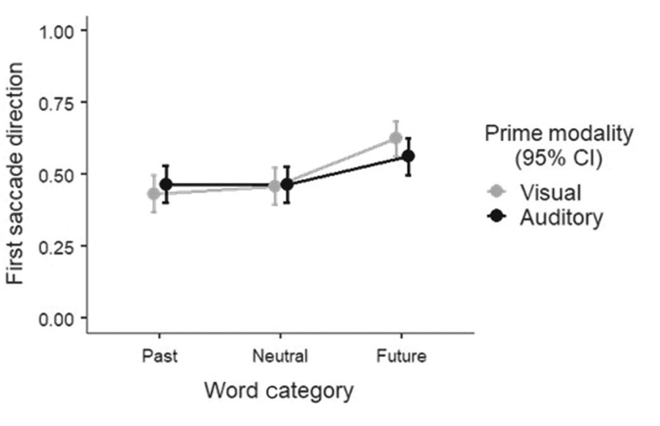

Fig. 3. Proportion of the first saccade direction (0 = left saccade, 1 = right saccade) predicted by prime modality and word category. Error bars represent 95% confidence intervals.

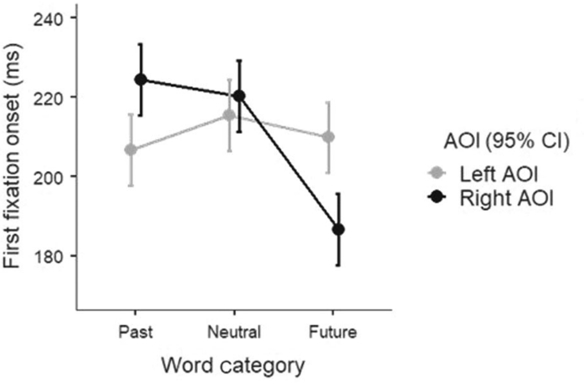

Fig. 4. Mean time to first fixation (in milliseconds) as a function of word category and area of interest (AOI). Error bars represent 95% confidence intervals.

the target was present or not. Due to a software error during the recording session, data from two participants are not reported in this analysis ($n = 57$).

An LMM analysis was conducted after a visual inspection of the plots revealing no significant violations of the normality and homoscedasticity assumptions. The model's fixed effects were prime modality (visual vs. auditory), word category (past vs. neutral vs. future), AOI (left vs. right), and their second- and third-order interactions. Random effects per participant ID, word ID, and word length were included to control for the variance that these factors might introduce in first fixation onset measures. Word length and its intercept were removed from the model as their variance was 0. The model was estimated using restricted maximum likelihood, with a Satterthwaite approximation of the degrees of freedom.

Results from the LMM analysis ($R^2_{marginal} = .01$; $R^2_{conditional} = .09$) converge with the previous reaction time responses by showing a main effect of word category, F (2, 45.3) = 30.49983, $p < .001$. Again, future-related words produced earlier first fixations ($M = 198$, $SE = 4.15$) than neutral ($M = 218$, $SE = 4.15$; $p < .001$) and past-related words ($M = 216$, $SE = 4.15$; $p < .001$). In line with what was previously observed, neutral words did not give rise to different first fixation onsets than past words ($p = .415$). An interaction between word category and AOI emerged, F (2, 10264.5) = 37.33751, $p < .001$. As predicted, the first fixations landed earlier on the AOI that was congruent with the orientation induced by the time-related word (Fig. 4). This means that participants' first fixation was launched earlier in the trial to the left AOI after a past-related word was presented ($M = 207$, $SE = 4.48$) than to the right AOI ($M = 224$, $SE = 4.55$, $p < .001$). Likewise, first fixations after future-related words reached the AOI located on the right earlier ($M = 187$, $SE = 4.53$) than on the left AOI ($M = 210$, $SE = 4.50$; $p < .001$). The time taken to the first fixation after neutral words was virtually the same in the left ($M = 215$, $SE = 4.48$) and right AOIs ($M = 220$, $SE = 4.54$; $p = .517$), suggesting that these words do not strongly induce any directionality. The remaining interactions were not significant (ps > .09). Therefore, first fixations following time-related words reached their congruently located AOIs faster, and this effect was not different between visual and auditory presentation.

To address the proposed asymmetry between congruent trials favoring the right space, a direct comparison between first fixation onset on the left AOI following past-related words and on the right AOI following future-related words, t (160) = 5.300, $p < .001$, confirmed that attention orientation benefits from time words that imply a rightward (vs. leftward) directionality, which overlaps with the LR scanning practices of our participants.

Finally, a linear regression was performed to predict response time based on eye gaze movement, in this case, the time taken by participants to land the first fixation. The regression equation was statistically significant, $R^2 = .163$, F (1, 55) = 10.69, $p = .002$. This indicates that the speed with which participants discriminated the target is predicted by the time participants took to land the first fixation on either interest area ($\beta = 1.236$, $p = .002$). That is, faster discrimination of targets results from faster, that is, biased, initial eye movement.

3. Experiment 2

The second experiment was designed to examine the generality of the effects observed in Exp. 1 in a linguistic community with the opposite script direction—unfolding from RL. Because Exp. 2 was collected online, it was not possible to provide gaze movement measures. Nevertheless, if we observe a reversal in time–space mappings and the proposed directional asymmetry observed in Exp. 1, then there are grounds for RL generalization. In Exp.2, we presented cue words in the visual modality alone because, in remote settings, it is virtually impossible to guarantee that participants wear the headphones that are necessary to receive the auditory stimuli and control the presentation volume, and so forth. We tested participants with the same cueing task, but with the time-related words translated to Arabic. The aim was to examine if the spatial mapping of time was reversed (i.e., past-right/future-left) and if RL reading—writing habits produce a left-sided advantage. Because attention starts from the center and is assumed to progress leftward, the same future-related words should produce a lateralized facilitation but now on the left space. This would indicate that scanning routines influence lateralized spatial attention. The predictions in terms of behavioral performance were the same as in Exp. 1—but mirrored. Target stimuli, procedure, and design were similar to Exp. 1.

3.1. Method

3.1.1. Participants

We recruited a total of 59 participants in line with the sample size estimation presented in Exp. 1. Due to a connectivity error between both platforms used (see the Procedure section for detail), three participants were unable to initiate the experiment and their data were not collected. The remaining 56 (36 men and 20 women, $M_{\text{age}} = 27.44$, $SD_{\text{age}} = 7.06$, four self-reported left-handed) were compensated for their participation through the crowdsourcing platform Prolific Academic. The sample size was determined a priori (Anderson et al., 2017) adjusting sample size effects for uncertainty and publication bias correction (desirable level of assurance = 0.90; statistical power = 0.80) based on the effect size proposed for temporal priming tasks (von Sobbe et al., 2019). Participants gave their consent to participate, and the experiment was approved by the Ethics Committee of the host institution (see Appendix 2 for a detailed sample characterization).

3.1.2. Cues

Cues were the 48 time-related words used in Exp. 1. The word set was translated from English to Arabic by a native Arabic-speaking translator (see Appendix 3 for the entire word list). The word list was pretested in an Arabic-speaking sample recruited and compensated via Prolific Academic ($n = 106$, 63 males, $M_{\text{age}} = 22.36$, $SD_{\text{age}} = 4.31$). Participants were presented with each word at the center of the screen and asked to move the slider below it toward the left or right depending on whether they thought the word referred to the future (0 = *far future*) or the past (100 = *far past*). Words were grouped in three semantic categories according to their mean ratings (F (2, 47) = 636.698, $p < .001$; past-oriented: $M = 61.46$, $SD = 3.42$; neutral: $M = 51.70$, $SD = 3.58$; future-oriented: $M = 21.44$, $SD = 2.88$; ps $< .001$ between groups). Words were randomly presented four times throughout the main experiment, two in each block.

3.1.3. Targets

Targets were the equivalents to the letters *q* and *p* marked on the standard Arabic keyboard (q = ض and p = ح). In each trial, only a ض (q) or a ح (p) was embedded in one of the two bilateral five-letter strings presented to the left and right sides of the screen. The distractor filler letters were the same across the experiment and randomized across trials. Because the task was conducted online, it was not possible to control for viewing distance to the screen or ascertain the dimensions of the screen on which the task was performed. Although we could not compute the degrees of visual angle that the target strings subtended, the strings were programmed to appear in the near peripheral visual fields. This peripheral presentation ensured that participants would not be able to discriminate the target unless lateralized gaze movements were made. The task could not be performed on mobile phones or tablets because these devices would compromise gaze movement direction.

3.1.4. Procedure

Participants were redirected from the recruitment platform Prolific Academic to Gorilla to perform the experiment. The experiment was programmed and ran in Gorilla Experiment Builder, a platform that provides tools for online behavioral research ensuring accurate and reliable online recording of reaction time measures (Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2020). Participants were first presented with an informed consent form. Upon agreement, they moved to the main task. They were asked to place their index fingers on the ض (q) and ح (p) keys before commencing the task. The general instruction was a speed-accuracy one (Fig. 5). After the task was completed, participants filled in a brief questionnaire about demographic information and the variables described in Appendix 2. All the information (task invite, informed consent, instructions of the task, final questionnaire) was given in Arabic. Behavioral responses were recorded through participants' keyboards by pressing the keys marked ض (q) or a ح (p).

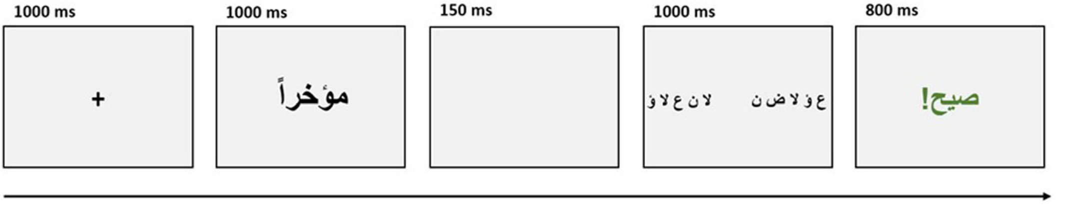

Fig. 5. Overview of the experimental procedure in Experiment 2.

The overall spatial cueing task, number of trials, and counterbalancing schema were the same used in Exp. 1, with the variation of targets being presented only in the visual modality. The task had a self-paced break between blocks. On average, participants completed the experiment in 20 min.

3.2. Results

3.2.1. Preliminary analysis

A visual inspection of the data revealed that six participants finished the experiment but did not produce any responses (all trials were missing responses). These participants were excluded from further analyses. Spurious responses below 100 ms were excluded (2.4%). Missing responses corresponded to 18% of trials. Response time was recorded from the target onset.[2]

3.2.2. Reaction time

We performed an LMM analysis on response times. As fixed effects, we included word category (past vs. neutral vs. future), target letter location (left vs. right), and their second-order interaction. We included random intercepts of word ID and participant ID. A visual inspection of the residual plots showed no severe violation of the homoscedasticity or normality assumptions. The model was estimated using restricted maximum likelihood with a Satterthwaite approximation of the degrees of freedom and was performed in jamovi software (version 1.2) with the GAMLj module.

The LMM ($R^2_{marginal} = .02$; $R^2_{conditional} = .07$) revealed a significant main effect of word category, F (2, 42.9) = 20.5814, $p < .001$. The main effect of the word category replicated what was observed in Exp. 1. Future-related words ($M = 666$, $SE = 5.58$), gave rise to faster detections than past-words ($M = 695$, $SE = 5.58$; $p < .001$). The speed in response times generated by future words was higher than that induced by neutral words ($M = 675$, $SE = 5.58$, $p = .058$). Past-related words were significantly slower in triggering responses than neutral words ($p < .001$). Hence, neutral words have assumed intermediate values. To address our prediction for congruency between the words and the location of the targets, we report the significant interaction of word category × target location, F (2, 42.9) = 32.7104, $p < .001$ (Fig. 6). We observed the typical congruency effect but now reversed, compared to what was observed in Exp. 1. Past-related words produced faster detection of the target on the right ($M = 680$, $SE = 6.38$) than on the left ($M = 710$, $SE = 6.55$; $p < .001$), indicating

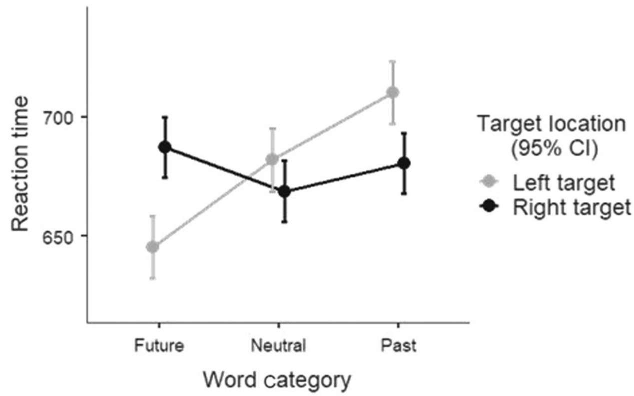

Fig. 6. Mean reaction time (in milliseconds) as a function of the word category and the target letter location. Error bars represent 95% confidence intervals.

that RL participants map the past on right spatial coordinates. Future-related words, which are spatially mapped on the left by RL speakers, produced faster target detection on the left ($M = 646$, $SE = 6.54$) than on the right ($M = 687$, $SE = 6.40$; $p < .001$). As hypothesized and replicating what was observed across measures in Exp. 1, neutral words produced similar detection latencies on the left ($M = 682$, $SE = 6.57$) and right space ($M = 669$, $SE = 6.38$; $p = .265$).

Finally, we moved to examine whether there was an asymmetric performance between congruent conditions derived from right-left scanning habits, that is, if the future-related words accelerated performance in the left target string above past-related words in the right target string. To this end, we report the comparison between the detection latencies observed for the two congruent conditions (future word – target left vs. past word – target right), $t\ (42.9) = -5.328$, $p < .001$. The results indicate that words with a leftward connotation (i.e., future-related) that imply the same flow of attention as that imposed by reading-writing activities produce advantages in detecting the target on the left more so than past-related words did on their corresponding target location (i.e., right).

To ensure that handedness could not account for the left-sided advantage (although the majority of participants reported higher right-hand skill), we compared response times as a function of the response key used to respond, namely, responses given by the ض (*q*) key (responded with the left hand) and by the ح (*p*) key (responded with the right hand). A paired samples *t* test showed no difference in response times when left and right hands were used to detect targets, $t\ (49) = 0.951$, $p = .346$.

4. Discussion

The two experiments we report here were conducted with two cultural samples with opposite reading and writing directions. Both experiments yielded results perfectly mirroring and confirming the symmetrical contributions of two factors to visual attention along the horizontal line. The first factor is reading direction, which in Portuguese and Arabic cultures is in opposite directions. The second factor is the grounding of time concepts on a horizontal line, with the past words that are anchored at the beginning of writing direction and future words at the direction in which reading evolves. Portuguese speakers read from left to right and associate future periods of time on the right and past words on the left. With Arabic speakers, it is the reverse. They read from right to left and associate future-related time words on the left and past-related time words on the right.

The research reported here shows that these two factors contribute jointly to visual attention and the detection latencies for the targets. The critical comparisons can be seen in the congruent trials in which, regardless of reading direction, the temporal meaning of the word matches the target location. That is, a comparison between both congruent conditions (e.g., for LR speakers in Exp1: past world – left target vs. future word – right target; for RL speakers in Exp2: past word – right target vs. future word – left target) revealed an advantage for prime-target combinations that are aligned with script direction (amplified right-sided effect for LR readers, amplified left-sided effect for RL readers). The difference in gaze movement and response latency between each trial represents the additional contribution reading direction has on visual attention. We found that each factor uniquely contributes to visual attention, regardless of whether participants read from LR (i.e., in Portuguese) or from RL (i.e., in Arabic).

This asymmetry between the congruent trials reveals the contribution of the habitual LR and RL language direction. This asymmetry shows that discrimination speed is not only driven by the semantic indication of the cue words (Ouellet, Santiago, Funes, & Lupiáñez, 2010; Torralbo et al., 2006; Weger & Pratt, 2008) but by reading and writing habits (Suitner & Maass, 2016). Furthermore, the consistency of this dual influence on how attention is driven in a detection paradigm is shown to be operating in similar ways in both cultures.

The current research advances prior work by experimentally disentangling two attention-orienting biases. This research identifies the two factors that operate jointly. As the first experiment shows, the visual and auditory representation of time converges (Lakens et al., 2011). Notably, the task in Experiment 1 comprised both unimodal cueing (cue and target belonging to the same modality; visual trials), and cross-modal cueing (cue and target belonging to different modalities; auditory trials). The first typically produced larger effects than the latter because stimuli processing benefits from the format similarity (Weatherford, Mills, Porter, & Goolkasian, 2015). Although participants may have been more prepared to process targets in visual trials (Spence & Santangelo, 2009), visuomotor performance in visual and auditory trials was comparable. This indicates that the presumed interference introduced by cross-modal presentation was insufficient to disrupt the effect of the attention-orienting forces. The visual-auditory convergence also shows that the lateral bias is not a by-product of the directional act of reading, or a "reading effect" (Jainta, Blythe, Nikolova, Jones, & Liversedge, 2015). Target detection did not benefit from the carryover effects of the reading process since auditory words (which do not activate the same motoric processes involved in reading) yielded the same pattern as visual words. This lends credence to our argument that asymmetries in visual attention are fueled by two co-occurring biases: the spatial referent that time words hold

(Bender & Beller, 2014) and the complementary directional practices instilled by language/culture (Suitner & Maass, 2016).

Finally, in Experiment 1, the examination of the direction of the first saccade showed that it was a response to the spatial referent of the cue word. This confirmed that noninformative cues were successful in producing the expected attention shifts. We should also highlight that word cues were derived from an abstract category and were not mere locatives (e.g., "left," "right") that are highly regular in everyday discourse (Hommel et al., 2001). The first saccade measure was complemented by the time to the first fixation that underscored the pattern observed in detection decisions. The imbalance in first fixation onset between congruent conditions favored cue–target configurations pertaining to the right and coherent with the participants' LR dominant script direction. This meshes well with the body of research reporting the impact of asymmetric reading-writing practices in distinct tasks (Bergen & Lau, 2012; Ouellet et al., 2010; Spalek & Hammad, 2005). Importantly, because word primes were presented centrally, attention was anchored at the screen's midpoint prior to target onset. Future words are mapped on the right space for Portuguese speakers and the left space for Arabic speakers. Consequently, these primes induced an attention scan that overlaps with the language script of both samples (Portuguese: LR; Arabic: RL), amplifying oculomotor performance relative to past words, which triggers a visual scan that goes against linguistic regularities and is costlier for participants (i.e., involves a greater effort). Neutral words produced intermediate performance levels, which fell in between those observed for past and future words. That is because these terms, although anchored horizontally, are not associated with left or right space, and thus did not trigger any systematic spatial pattern.

An important limitation of this research is that we were not able to collect gaze movement for the Arabic-speaking population. Although the mirrored detections in the two experiments enable us to infer that Arabic participants would display a symmetric attentional performance to that observed for Portuguese participants, we encourage other researchers to confirm the spatial bias in RL linguistic communities. The same applies to the testing in the auditory modality. In sum, broader evidence is needed to establish that asymmetries in visuomotor performance are derived from the added influence of reading direction on embodied groundings.

To conclude, in a cross-cultural set of studies, we demonstrated that two sources of bias, namely, the grounding of time words and cultural writing habits, operate in conjunction to induce an asymmetric movement direction that constrains detection decisions. Inherently nonspatial words triggered not only spatially consistent responses but these were further modulated by script direction and convergent across modalities. This research informs researchers about people's spatial preferences when scanning the surrounding environment.

Acknowledgments

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Data Availability Statment

The data that support the findings of this study are publicly available in the Open Science Framework repository at https://osf.io/4dspn/?view_only=9e1e0f5d66ed475097a89f1ebec2876c

Notes

1 The number of missing responses was not significantly different across conditions (prime modality × word category × target location): F (2, 68) = 1.979, $p = .146$.
2 The number of missing responses was not significantly different across conditions (word category × target location): F (2, 74) = .0109, $p = .989$.

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Appendix 1

Table 1 Experimental materials from Experiment 1

Past	Neutral	Future
Passado (past)	*Hora* (hour)	*Futuro* (future)
Ontem (yesterday)	*Minuto* (minute)	*Amanhã* (tomorrow)
Anteriormente (previously)	*Milénio* (millennium)	*Posteriormente* (subsequently)
Antes (before)	*Sazonal* (seasonal)	*Depois* (after)
Antigamente (formerly)	*Contemporâneo* (contemporary)	*De seguida* (next)
Recentemente (recently)	*Diário* (daily)	*Depois de amanhã* (after tomorrow)
Anteontem (before yesterday)	*Semana* (week)	*Em breve* (soon)
Há pouco tempo (not long ago)	*Mês* (month)	*Imediatamente* (immediately)
Apareceu (he showed up)	*Trimestre* (quarter)	*Aparecerá* (he will show up)
Procurou (he looked for)	*Quinzena* (fortnight)	*Procurará* (he will look for)
Conduziram (they drove)	*Duração* (duration)	*Conduzirão* (they will drive)
Decidiram (they decided)	*Hoje* (today)	*Decidirão* (they will decide)
Disse (he said)	*Momento* (moment)	*Dirá* (he will say)
Foi (he went)	*Temporada* (season)	*Irá* (he will go)
Fizeram (they did)	*Data* (date)	*Farão* (they will do)
Viram (they saw)	*Dia* (day)	*Dirão* (they will say)

Appendix 2

Sample characterization

At the end of the experiment, we collected additional information to characterize our sample better. Participants' mother tongue was Arabic, and they were nationals of the following Arabic-speaking countries: Iraq (1), Egypt (8), Jordan (5), Lebanon (4), Libya (1), Morocco (9), Palestine (4), Qatar (2), Saudi Arabia (2), Syria (5), Tunisia (8), and UAE (1). The majority of the participants (82%) had university degrees, and the remaining had attended high school. All participants except one reported speaking one additional language. These were English (73.47%), French (14.29%), Spanish (6.12%), German (4.08%), and Turkish (2.04%). Forty-seven participants reported having lived abroad in the following countries: Belgium (1), Brazil (1), Canada (3), Czech Republic (1), Denmark (1), Estonia (1), France (10), Germany (6), Greece (1), Hungary (2), Italy (1), Jordan (2), Latvia (1), Malaysia (1), Mexico (1), Portugal (1), Saudi Arabia (1), Spain (1), Sweden (2), Turkey (1), the United Kingdom (7), the United States (1). The minimum period spent abroad was 1 year and a maximum of 15 years. To the question "Do you use social media (Facebook, Twitter, Instagram) in Arabic?" 84% of participants said yes. To the question "Do you watch movies/tv-shows/read books in Arabic?" 60% of participants said yes. To the question "Do you read the news (news websites, newspapers) in Arabic?" 54% of participants said yes. Finally, 84% of the participants said yes to the question, "Do you have family conversations in Arabic in your everyday life?" When asked to move a slider on a horizontal line to indicate "How much contact in everyday life do you have with your native language - Arabic?" the average response was 58.54%, and How much contact in everyday life do you have with languages that are written from LR (e.g., English, French, …)? the average response was 47.7%.

Appendix 3

Table 2 Experimental materials from Experiment 2

Past	Neutral	Future
ماضي (past)	ساعة (hour)	مستقبل (future)
أمس (yesterday)	دقيقة (minute)	غداً (tomorrow)
سابقاً (previously)	ألفيّة (millennium)	لاحقاً (subsequently)
قبل (before)	موسمي (seasonal)	بعد (after)
فيما مضى (formerly)	معاصر (contemporary)	تالي (next)
مؤخراً (recently)	يومي (daily)	بعد غدٍ (after tomorrow)
قبل أمس (before yesterday)	أسبوع (week)	قريباً (soon)
ليس من مدة طويلة (not long ago)	شهر (month)	حالاً (immediately)
ظهرَ (he showed up)	ربع سنة (quarter)	سيظهر (he will show up)
بحثَ عن (he looked for)	أسبوعان (fortnight)	سيبحث عن (he will look for)
قادوا (they drove)	مدّة (duration)	سيقودون (they will drive)
قرروا (they decided)	اليوم (today)	سيقررون (they will decide)
قالَ (he said)	لحظة (moment)	سيقول (he will say)
ذهبَ (he went)	موسم (season)	سيذهب (he will go)
فعلوا (they did)	تاريخ (date)	سيفعلون (they will do)
رأوا (they saw)	يوم (day)	سيقولون (they will say)