Access to time-related words biases attention in horizontal space

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Existing research suggests that processing of time-related words is accompanied by the displacement of visual attention (Walsh, 2003). For example, word recognition reaction times (RTs) are faster if words related to the past are presented in leftward space (or are judged with the left key), and when words related to the future are presented in rightward space (or are judged with the right key) (Tarralbo et al., 2006). Moreover, speakers of different languages (with some exceptions) associate future events with rightward/forward and past events with leftward/backward orientation and motion (Núnež & Sweetser, 2006; Boroditsky, 2000; 2018). Furthermore, time concepts engage a complex spatial mapping space where individual concepts may be represented along horizontal, vertical, and sagittal axes (Miles et al., 2011; Ding et al., 2020). Existing studies document these regular spatial biases in tasks using time-space metaphors (e.g., Núñez & Sweetser, 2006), deictic time words (e.g. Woodin & Winter, 2018), and words denoting past and future events (e.g. Boroditsky, Fuhrman & McCormick, 2011). However, fewer studies focus on spatial references of the individual time units, such as months, days of the week, or hours of the day (e.g., Gevers et al., 2003; He et al., 2013), and there is no research that compares access to these distinct time concepts by using the same experimental task.

In the current study, we used distinct time units, i.e., days (e.g., Monday), months (e.g., February), and hours (e.g., 9 a.m.) in a horizontal line bisection study. We selected the horizontal axis due to its prevalence in mapping of temporal concepts (Woodin & Winter, 2018). 57 native Russian speakers (37 females, age 21.5 ± 4.1 years) listened to temporal word stimuli and then used the mouse cursor to indicate where that unit may be located on a line whose extreme points biased left, right, or central positioning of the processed word. Thus, the following IVs were manipulated in the design: Time Unit (Hours/Days/Months), Word Bias (Left/Right), and Scale Bias (Left/Center/Right). Hypothesized left (e.g., Monday) and right (e.g., Sunday) semantic biases were selected based on previous findings (Gevers et al., 2003; Price, 2009; Leone et al., 2018).

RTs and response coordinates (x) were recorded and analyzed using ANOVAs and pair-wise t-tests. Means for each combination of the factors are presented in Tables 1, 2. The analyses revealed that temporal semantic biases caused shift in participants' responses in the corresponding direction (x-coordinates) for all time units. In addition, task-related RTs were faster in congruent conditions (e.g., left semantic bias + left position) for days and hours, but not for months. Moreover, RTs were graded in the following order: hours < days < months. The findings provide evidence that processing of time units biases attention in horizontal space. In general, our findings are consistent with the mental timeline concept (Bender & Beller, 2014; Bonato et al., 2012) with left-biased time units located in the leftward space and right-biased time units in the rightward space. However, we conclude that while horizontal mapping of time is relatively universal, the horizontal shift of spatial attention is rather observed in processing of hours and days, as compared to months. It may be caused by the influence of both other associative representations (e.g., calendar, circle) and other domains (e.g., numerical SNARC effect) (cf. He, et al, 2020; Seymour, 1980).

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Table 1. Mean reaction times; standard errors are in parentheses.

Reaction Time (msec)						
	Word Bias					
	left			right		
	Scale Bias					
	left	center	right	left	center	right
Time Unit						
Hours	1770 (53)	1983 (62)	1967 (58)	1937 (64)	2016 (68)	2102 (69)
Days	1866 (58)	2194 (63)	2060 (63)	1969 (62)	2218 (69)	1997 (65)
Months	1998 (63)	2259 (83)	2242 (78)	2029 (64)	2289 (78)	2153 (74)

Table 2. Mean response coordinates (in height units); standard errors are in parentheses.

X-coordinates of Response (height units)						
	Word Bias					
	left			right		
	Scale Bias					
	left	center	right	left	center	right
Time Unit						
Hours	-.313 (.009)	-0.036 (.013)	0.275 (.015)	-.278 (.012)	-.006 (.010)	.246 (.013)
Days	-.314 (.010)	-.011 (.009)	.270 (.012)	-.306 (.010)	.009 (.008)	.302 (.011)
Months	-.292 (.009)	-.011 (.007)	.235 (.013)	-.279 (.012)	-.018 (.010)	.260 (.012)