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## WHEN NEXT WEDNESDAY'S MEETING IS A RED-LETTER DAY: THE EFFECT OF RED ON TEMPORAL REASONING

**Abstract:** Interpretation of the ambiguous statement “Next Wednesday’s meeting has been moved two days” depends on dichotomous metaphorical perspectives on time. The ego-moving perspective, which implies a future-bound movement, renders the meeting postponed to next *Friday*. Alternatively, the time-moving perspective, which implies a past-bound movement, translates the situation into an earlier occurrence to next *Monday*. Motor experiences in space and those grounded as such can influence the preferred perspectives on time. Emerging evidence suggests that sensory experiences can likewise exert an impact. Along these lines and focusing on visual perception, this research examined the unexplored effect of color on temporal reasoning. We found that exposure to the word “meeting” styled in red (*versus* black) font heightened arousal, which in turn reduced perceived temporal distance that maps onto the time-moving perspective, resulting in a *Monday* interpretation (Experiment 1). We further demonstrated that the strength of the association between red and the time-moving perspective was conditional on levels of arousal (Experiment 2). By documenting the novel contributor of color to the malleability of temporal perspective preferences and the underlying psychological mechanism thereof, our work adds to the literature on color and psychological functioning and underscores the significance of sensory perception in temporal cognition.

**Key words:** Time/ego-moving perspective; Red; Arousal; Perceived temporal distance; Embodied cognition

### 1. Introduction

As fundamental as time is to human existence, it cannot be directly captured by our sensory apparatus. According to Conceptual Metaphor Theory, the understanding of this abstract construct is achieved through metaphorical mapping from the more perceptually rich domain of space (Lakoff & Johnson, 1980). To appreciate the spatial undergirding of temporal conceptualization, one needs to look no further

than the miscellany of spatiotemporal metaphors in common expressions. Reflecting sequential temporal frame of reference whereby events in time are located in relation to one another, the spatial terms “front” and “back” are metaphorically mapped onto temporal concepts denoting “earlier” and “later”, as in “The Spring Festival is followed by the Lantern Festival”. Contrastively and using the deictic temporal reference frame whereby events are fixed relative to the metaphorical location of the ego (i.e., the here and now), the same positional terms are employed in service of conceptualizing “future” and “past”, as in “She has never looked back because she has the whole of her life in front of her” (Duffy & Vyvyan, 2017; Moore, 2011). The interval between events in time is likewise metaphorically represented in terms of distance between locations in space, as in “Short videos can serve an educational purpose in the long run” (Casasanto & Boroditsky, 2008).

The focus of the current research is on the binary deictic metaphorical perspectives on time, which contrast in direction of travel (past-bound vs. future-bound) and temporal agency (time vs. ego) (McGlone & Harding, 1998). To illustrate, an event may be envisioned as moving from the future toward the stationary self and continuing on in the direction of the past. This is conceptualized as the time-moving perspective and exemplified by the expression “The Year of the Snake has arrived”. Conversely, one may envisage oneself as the moving entity toward an awaiting future event, which is conceptualized as the ego-moving perspective and instantiated in the expression “We are approaching the Lunar New Year” (Clark, 1973; Huumo, 2017; Lakoff & Johnson, 1999).

The dichotomy of temporal perspectives therefore allows for their malleability, which is commonly examined via the temporal disambiguation paradigm (i.e., “Next Wednesday’s meeting has been moved forward two days”) (Boroditsky, 2000). The statement is ambiguous in that the adverb “forward” delimiting the direction of the movement of the meeting is unspecified, thereby allowing divergent directions to qualify *forwardness* dependent on and reflective of the temporal perspective of choice. Concretely, if the forward movement of the meeting is reasoned to be toward the future, whereby it is rescheduled to take place later than is originally planned (i.e., next *Friday*), then the temporal perspective taken in this case would be the ego-moving perspective with common future-ward movement. Contrarily, if the forward movement is reasoned to be in the direction of the past, whereby the meeting is to occur ahead of the schedule (i.e., next *Monday*), then the temporal perspective adopted in this case would be the time-moving perspective with shared past-ward movement (McGlone & Harding, 1998).

## 1.1 Motor experiences and temporal perspectives

An accumulation of studies has shown that changes in spatial experiences can result in different temporal perspective preferences in the resolution of the “Next Wednesday’s meeting” ambiguity (Boroditsky, 2000; Matlock et al., 2011). For

example, Boroditsky and Ramscar (2002) compared the disambiguation responses of passengers who had just touched down at an airport with those of people who were there waiting to collect others and found that the former chose the ego-moving perspective significantly more frequently than the latter, suggesting that experience of movement through space facilitated the thought about movement through time. Importantly, because the understanding of fictive motion involves the mental simulation of motion (Matlock, 2004), the influence on temporal thinking does not necessitate actual movement. Indeed, Matlock et al. (2005) reported that participants primed with fictive motion describing a road going away from the location where they were (analogous to the ego-moving perspective) tended to respond *Friday*, whereas those primed with the reverse in the form of a road coming toward their current location (analogous to the time-moving perspective) tended to respond *Monday*.

Since people's metaphorical perspectives on time can vary as a function of spatial motion, it is logical to assume that non-spatial factors grounded as such may exert a similar effect (Hauser et al., 2009). As a key example, on the strength that emotion triggers embodied responses, such that positive emotion activates behavioral approach and negative emotion behavioral avoidance (Chen & Bargh, 1999), Margolies and Crawford (2008) predicted that positivity/negativity would be associated with the ego/time-moving perspective through shared approach/avoidance motivation. As predicted, they found that participants who had engaged in thought about a future event they felt enthusiastic about, thereby inducing strong positive emotion preferred the ego-moving perspective. In contrast, those who had engaged in thought about a future event they dreaded facing, thereby inducing strong negative emotion favored the time-moving perspective. More recently, given that the Taoist doctrine *wu-wei* (*none action*: inaction) emphasizes a passive approach to the vicissitudes of the world and thereby habituates believers practicing this religion to lower levels of personal agency (Moon, 2015) and given that lack of personal agency is spatially represented by avoidance-related motivation and as such was related to the time-moving perspective (Richmond et al., 2012), Li and Cao (2020) predicted that Taoists, relative to atheists, should therefore be more inclined toward the time-moving perspective. Aligning with their prediction, the results showed that Taoism practitioners preponderantly took the time-moving perspective, which was in stark contrast to their atheist counterparts who were neutral in perspective-taking. Taken together, these empirical findings suggest that non-spatial experiences that tap into approach-/avoidance motivation rooted in spatial motion can equally influence metaphorical perspectives on time.

## **1.2 Perceived temporal distance and temporal perspectives**

Other than being contrary in spatial motivation, the dichotomous temporal perspectives also differ in deixis, that is, direction of movement in relation to the cognizer's current position in time (Duffy & Feist, 2017), causing differential

perceptions of temporal distance to the future as a result. Specifically, the ego-moving perspective presupposes a longer perceived distance to the future, whereas the time-moving perspective presupposes a shorter perception. Diverse streams of findings support this inference. For example, in an investigation into the influence of temporal perspectives on task duration judgments, Boltz and Yum (2010) found that participants primed with the ego-moving perspective perceived the distance to the conclusion of the experimental session to be significantly farther than those primed with the time-moving prime. More pertinently, in an examination of how lexical and constructional factors may influence the resolution of the “Next Wednesday’s meeting” ambiguity, Feist and Duffy (2015) found that participants gave more *Monday* responses when the meeting was “brought forward” than when it was “taken forward”. This is because “bring” encodes deictic motion toward the self, whereas “take” encodes deictic motion away from the self, thereby shortening and lengthening the subjective distance, respectively. Providing convergent evidence, a later study conducted by the same authors found that briefly adopting a high-power pose, which features limb movement away from the torso yielded a significantly greater preference for the ego-moving perspective than adoption of a low-power pose that features limb movement directed toward the torso (Duffy & Feist, 2017). An additional line of evidence associating perceived temporal distance with temporal perspectives stems from the work on intertemporal decision-making (Crilly, 2017). In a most recent study on the influence of temporal perspectives on consumer behavior, Xu et al. (2024) found that compared to a product delivery scenario framed from the time-moving perspective (i.e., “The delivery day is approaching”), framing the equivalent from the ego-moving perspective (i.e., “You are approaching the delivery day”) made customers more likely to opt for the express delivery service as a result of the ego-moving perspective lengthening the perceived distance to the delivery day and provoking impatience.

### **1.3 Arousal and perceived temporal distance**

Since temporal perspectives imply perceived temporal distance (Duffy & Feist, 2017), it follows that factors that can vary perceived temporal distance should in turn influence temporal perspective preferences. One such factor is arousal. Arousal has an established effect on subjective time perception, with high-arousing stimuli generating a shorter perception than low-arousing ones regardless of valence (Droit-Volet & Meck, 2007; Noulhiane et al., 2007). For example, Campbell and Bryant (2007) measured skydivers’ perceived time duration of the skydive and found that higher levels of excitement recorded before and soon after landing were associated with shorter estimation. Similarly, a later investigation into the effect of counting direction on time judgements revealed that counting downward generated significantly higher ratings of arousal and resulted in significantly shorter estimate of task duration compared to counting upward (Shalev & Morwitz, 2013). Because areas of the brain

involved in processing time that has elapsed are also engaged in gauging time that has yet to come (Kim & Zauberger, 2019), the adverse effect of arousal on duration estimation parallels its effect on projection of temporal distance to the future. As a case in point, Van Boven and collaborators (2010) found that people perceived negative events they dreaded happening as psychologically closer than positive events they were looking forward to because negative events were emotionally more arousing than positive ones. Providing corroboratory evidence, Gu and Tse (2016) found that narrative perspective shift from first-personal pronoun “I” to third-personal pronoun “s/he”, compared to the reversed shift in autobiographical memory attenuated the emotional intensity of and lengthened the psychological distance to both positive and negative recalled events. Echoing the inverse relationship between arousal and perceived temporal distance, a more recent study showed that participants primed with coffee cues reported a significantly shorter time horizon until the engagement of future activities than those primed with tea cues. For explanation, measures of both psychological arousal (i.e., self-reported) and physiological arousal (i.e., heart rate) further revealed coffee to be rated as more arousing than tea (Chan & Maglio, 2019).

#### **1.4 The color red and arousal**

Given that temporal perspectives embed differential perceptions of temporal distance (Duffy & Feist, 2017) and that arousal can vary perceived temporal distance (Chan & Maglio, 2019), it stands to reason that factors which can modulate arousal should potentially influence temporal perspective preferences through varying perceived temporal distance. The factor of primary interest in the present research is the color red. Prior work on color psychology has converged toward red being highly arousing, identifying it with descriptors such as “exciting” and “stimulating” (Briki & Hue, 2016; Wexner, 1954). For example, in semi-structured interviews where participants accorded emotions and meanings to color terms, Clarke and Costall (2008) found that whilst green and blue were more frequently described using low-arousal adjectives like “peaceful” and “relaxing”, red was described in terms of high-arousal emotions such as “anger” and “passion”. Consistent with semantic associations, psychological and physiological measures (e.g., skin conductance responses) of the effects of color on arousal revealed red stimuli (e.g., room and lighting) to be more arousing relative to blue ones (Jacobs & Hustmyer, 1974; Küller et al., 2009; Rajae-Joordens, 2010; Wilson, 1966). Providing further circumstantial evidence, data from consumer research showed that a red (vs. blue) background elicited higher bid jumps in eBay auctions and fewer price offers in negotiations, which was driven by red heightening arousal that subsequently induced aggressive intention against other bidders and the seller (Bagchi & Cheema, 2013). Elsewhere, the influence of red on arousal perception in an achievement context found that test-relevant pictures set in a red frame were perceived to be more arousing than blue-framed ones (Buechner &

Maier, 2016). More recently, in harmony with the Yerkes-Dodson law which proposes that high arousal is more advantageous than low arousal for simple tasks, whereas low arousal is more advantageous than high arousal for difficult tasks (Yerkes & Dodson, 1908), Hong and collaborators (2022) demonstrated that whilst the more challenging dart-throwing performance was better when the stimulus was blue than when it was red, the less complicated handgrip performance was better in the red condition than in the blue one, thereby offering indirect evidence connecting red/blue to high/low arousal. Collectively, these multiple findings converge toward the conclusion that the color red is associated with high arousal.

## 2. The present study

Concatenating the triadic strands of reviewed literature, namely, the association between red and arousal (Buechner & Maier, 2016), the association between arousal and perceived temporal distance (Chan & Maglio, 2019), and the association between perceived temporal distance and temporal perspectives (Duffy & Feist, 2017), the current research sought to investigate whether red may influence temporal perspective preferences through arousal and perceived temporal distance. To this end, Experiment 1 compared the answers to the “Next Wednesday’s meeting” question where the word “meeting” was styled in red font with those to the same question where the word retained its default black font. Evoked arousal and perceived temporal distance were tested as mediators. Experiment 2 manipulated arousal adventitious to the manipulation of color to provide substantiating evidence for the mediating role of arousal in the effect of red on temporal perspectives.

### 2.1 Experiment 1

Based on the tripartite link surveyed above, we hypothesized that in the interpretation of the “Next Wednesday’s meeting” ambiguity, people exposed to the “meeting” in red, relative to the word in black would be more prone to the time-moving perspective, resulting in more next *Monday* interpretations. This tendency was further postulated to be driven sequentially by heightened arousal and the consequent reduction in perceived temporal distance.

#### 2.1.1 Participants

The sample size for the experiment was determined using G\*Power 3.1 (Faul et al., 2009). *A priori* power analysis with a medium-sized effect ( $d = 0.50$ ) and 0.80 power at the alpha level of 0.05 assumed indicated a minimum sample size

of 128. 142 students were recruited from a university in southwest China. They were distributed between the red condition and the black (control) condition in a random and even manner. 3 participants in the former condition and 4 participants in the latter condition did not complete the questionnaire and therefore their data were excluded, leaving 68 samples for the red condition (43 females,  $M_{\text{age}} = 22.43$  years,  $SD = 2.60$ ) and 67 for the black condition (46 females,  $M_{\text{age}} = 21.81$  years,  $SD = 2.64$ ). Data were entered in SPSS 25.0 for statistical analyses. There was no significant difference between conditions in age or gender ( $ps > 0.05$ ). All participants provided informed consent and were each monetarily compensated for their time.

### 2.1.2 Materials and procedure

The experiment was conducted in quiet classrooms using pen and paper. Participants were informed of the purpose of the experiment, which was to answer a short survey on time management in the form of a seven-page booklet. First, they gave informed consent and provided demographic information of age, gender, and major. Then, participants in both conditions were presented with the same target temporal question that read, “下周三的会议移动了两天。移动后的会议在哪天举行? (*Next Wednesday's meeting has been moved two days. What day is the meeting now that it has been moved?*)” (Qin, 2024a). The only thing that differentiated the two conditions was the font color of the temporal event in question, i.e., “会议(meeting)”, with that for the red condition being red, as in “会议(meeting)”. Concretely, the HSB (Hue, Saturation, Brightness) values for the red font were 0%, 100%, 100%, corresponding to 255, 0, 0 in the RGB (Red, Green, Blue) model. Those for the black font were 0 on all the dimensions for both models. Noticeably, the Chinese adaptation is rid of the adverb “forward”. The justification for its removal is that the Chinese spatiotemporal term “前(*forward*)”, when used in an exclusively temporal context, is readily equated with an event being advanced in time, due in no small part to the assimilation of conventionalized expressions such as “提前出发(*lift forward exit start: earlier departure*)” (Li & Cao, 2020; Qin, 2024a; 2024b). Clipping the adverb therefore transposes the seat of ambiguity to the verb “move”, with its direction being either future-bound or past-bound. As such, disambiguation is done in the same way as the English original (McGlone & Harding, 1998). To wit, future-ward movement fits in with the ego-moving perspective, resulting in a deferral to next *Friday*. In contrast, past-ward movement ties in with the time-moving perspective, resulting in an advancement to next *Monday*. To obviate an *either-or* response, two choices were provided (“A. Next Monday” or “B. Next Friday”) for participants to pick from.

This was followed by the measurement of arousal. Previous research has employed both psychological and physical measures of arousal (e.g., Chan & Maglio, 2019), which do not necessarily yield homogeneous results (Mauss et

al., 2004). Here, we only measured psychological arousal, the reason being that metaphorical conceptualization of temporal movement should be qualified as a cognitive process, to which perceived arousal may bear more relevance (Xu et al., 2024). Accordingly, we followed a precedent (Kim & Zauberger, 2019) and asked participants to assess their emotional states in response to the meeting in accordance with the arousal dimension of the Self-Assessment Manikin (Mehrabian & Russell, 1974). Specifically, the dimension consists of six bipolar adjectives: “stimulated – relaxed”, “excited – calm”, “frenzied – sluggish”, “jittery – dull”, “wide awake – sleepy”, and “aroused – unaroused” and each continuum ranges in a descending order from “9 = *very much so*” to “1 = *not in the least*”, with higher total score indicating greater arousal. Participant’s ratings of the six items (Cronbach’s alpha = 0.890) were each averaged to index their subjective arousal. Then, they went on to judge how psychologically distant they perceived the coming meeting to be on two 10-point scales (“1 = *it feels like it may occur tomorrow*” to “10 = *it feels like very far away from now*” and “1 = *it feels very near*” to “10 = *it feels very distant*”) adapted from two analogous studies (Mei et al., 2018; Van Boven et al., 2010). Scores of the two items ( $r = 0.804, p < 0.001$ ) were averaged to create an index of perceived temporal distance.

Subsequently, participants evaluated how anxious and angry they felt toward the meeting, also on a 9-point Likert scale, with higher number indicating greater emotional intensity. The inclusion of these two particular emotions was motivated by their respective connection with red, which may potentially confound or even reverse the hypothesized effect. To elaborate, there is evidence associating red with anxiety (Jacobs & Suss, 1975; Reeves et al., 1978), which is related to the time-moving perspective through shared avoidance-related motivation (Richmond et al., 2012). Assuming that red evoked greater anxiety relative to black, we would anticipate the preference for the time-moving perspective consistent with the hypothesis. However, in this case, an alternative causal pathway whereby red directly induced anxiety which implicates avoidance motivation would warrant further investigation. Moreover, much evidence indicates that red is associated with anger (Kaya & Epps, 2004; Sutton & Altarriba, 2016), which is linked to the similarly approach-based ego-moving representation (Hauser et al., 2009). If red, compared to black elicited greater anger, a high-arousal emotion (Rowe & Fitness, 2018), then it would prompt more *Friday* interpretations indicative of the ego-moving perspective. This would largely contradict the proposed chain of effects, as in this case, instead of shortening the perceived temporal distance, the high arousal manifest in anger would be actually lengthening it, hence the necessary consideration of the role of anger.

As mentioned before, temporal perspective preferences can vary as a function of event valence (e.g., Zheng et al., 2019). Given that the attested ambiguousness of the “Next Wednesday’s meeting” question is contingent on the temporal event being in black (Li, 2020) and that a word in red can connote evaluative valence

(Moller et al., 2009), rendering the “meeting” in red would make it less evaluatively neutral than when it is in black. Assessing participants’ subjective feelings toward the “meeting” in different font colors was thus necessary to control for yet another potential confounding factor of event valence in the effect of red on the preferred perspectives on time. Accordingly, participants proceeded to rate how they felt about the meeting on an ascending scale of “1 = *dreading it*” to “9 = *looking forward to it*”, with the midpoint “5 = *indifferent*”. Finally, two supervenient questions asking “How many hours do you normally spend on assignments every day?” and “What time of the day do you find yourself most productive?” were appended to bolster the cover story.

### 2.1.3 Results and discussion

In consistence with our hypothesis, temporal perspective preferences differed significantly between conditions, as evidenced by a chi-square test of independence,  $\chi^2_{(1,133)} = 9.068, p = 0.003$ , Cramer’s  $V = 0.259$ , 95% CI = [0.002, 0.005]. As displayed in **Figure 1**, the majority of participants in the red condition (44 out of 68 or 64.71%) preferred the time-moving perspective by judging the meeting to be brought earlier to next *Monday*, which was markedly different from the rest who opted for the ego-moving perspective and responded next *Friday* ( $Z = -2.304, p = 0.021$  by a sign test). In contrast, participants in the black condition did not exhibit any perspective bias (26 *Mondays* vs. 41 *Fridays*;  $Z = -1.710, p = 0.087$ ). Also as hypothesized, participants in the red condition reported higher levels of arousal ( $M = 4.461, SD = 1.070$ ) than those in the black condition ( $M = 2.822, SD = 0.810$ ). An independent samples *t*-test revealed this difference to be statistically significant,  $t(133) = -10.027, p < 0.001, d = -1.307$ , 95% CI = [-1.963, -1.316]. Furthermore, judgment of temporal distance also differed significantly between conditions, manifest in the fact that psychological distance to the future meeting was perceived to be significantly shorter in the red condition ( $M = 3.904, SD = 1.179$ ) than in the black condition ( $M = 5.134, SD = 1.437$ ),  $t(133) = 5.440, p < 0.001, d = 1.230$ , 95% CI = [0.783, 1.677]. In addition, ancillary analyses indicated no significant difference between conditions regarding anxiety, anger, and subjective feelings toward the meeting ( $ps > 0.05$ ), which also did not bear on temporal perspectives ( $ps > 0.05$ ) (see **Table 1** for details).

Correlation analyses were then performed. Presented in **Table 2**, the results indicated significant positive correlations between the study variables. To wit, color was significantly positively correlated with arousal,  $r = 0.656, p < 0.001$  but significantly negatively correlated with perceived temporal distance,  $r = -0.427, p < 0.001$  and temporal perspective,  $r = -0.259, p = 0.002$ . Arousal was significantly negatively correlated with perceived temporal distance,  $r = -0.752, p < 0.001$  and temporal perspective,  $r = -0.519, p < 0.001$ . Perceived temporal distance was significantly positively correlated with temporal perspective,  $r = 0.736, p < 0.001$ .

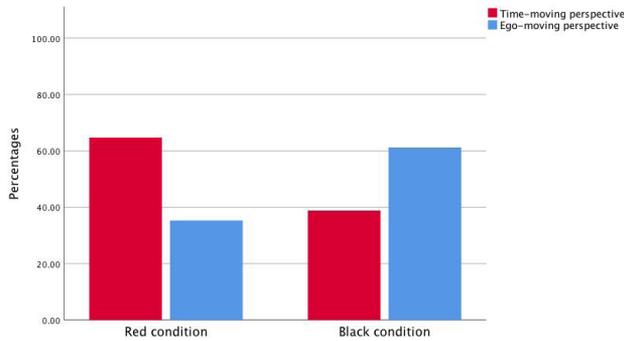


Figure 1. Percentages of the time-moving perspective and the ego-moving perspective between the red condition and the black condition (Experiment 1).

Table 1. Descriptive statistics of study variables and independent samples *t*-tests between the red condition and the black condition (Experiment 1).

Variable	Red condition	Black condition	<i>t</i>	<i>p</i>	<i>d</i>	95%CI	
	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )				Lower	Upper
Arousal	4.461 (1.070)	2.822 (0.810)	-10.027	<0.001	-1.307	-1.565	-1.050
Perceived temporal distance	3.904 (1.179)	5.134 (1.437)	5.440	<0.001	0.850	0.541	1.159
Anxiety	3.162 (1.784)	2.836 (1.629)	-1.188	0.237	-0.204	-0.544	0.136
Anger	2.278 (1.091)	2.030 (1.128)	-1.307	0.193	-0.224	-0.564	0.115
Subjective feelings	5.529 (1.849)	5.045 (1.236)	1.788	0.076	0.485	-0.052	1.021

Note. *M* = Mean, *SD* = Standard Deviation, CI = Confidence Interval.

Table 2. Pearson correlations of the study variables (Experiment 1).

Variable	1	2	3	4	5	6	7
1. Color	-						
2. Arousal	0.656***	-					
3. Perceived temporal distance	-0.427***	-0.752***	-				
4. Temporal perspective	-0.259**	-0.519***	0.736***	-			
5. Anger	0.113	0.420	-0.092	0.025	-		
6. Anxiety	0.096	0.022	0.024	-0.009	-0.129	-	
7. Subjective feelings	0.153	0.091	-0.021	0.068	0.156	-0.060	-

Note. \**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

These positive significant correlations allowed us to test the hypothesized serial mediation effect (red → higher arousal → shorter perceived temporal distance → time-moving perspective). To do this, we first ran a series of regressions analyses for individual paths. The results are summarized in **Table 3**. Specifically, color (1 = red vs. 0 = black) was significantly negatively associated with temporal perspective

(1 = ego-moving vs. 0 = time-moving perspective),  $B = -0.259$ ,  $SE = 0.084$ ,  $p = 0.002$ , 95% CI = [-0.425, -0.093], significantly positively associated with arousal,  $B = 1.640$ ,  $SE = 0.164$ ,  $p < 0.001$ , 95% CI = [1.316, 1.963], and significantly negatively associated with perceived temporal distance,  $B = -1.230$ ,  $SE = 0.226$ ,  $p < 0.001$ , 95% CI = [-1.677, -0.783]. Moreover, arousal was significantly negatively associated with both perceived temporal distance,  $B = -0.867$ ,  $SE = 0.066$ ,  $p < 0.001$ , 95% CI = [-0.998, -0.737] and temporal perspective,  $B = -0.207$ ,  $SE = 0.030$ ,  $p < 0.001$ , 95% CI = [-0.266, -0.149]. Finally, perceived temporal distance was significantly positively associated with temporal perspective,  $B = 0.255$ ,  $SE = 0.020$ ,  $p < 0.001$ , 95% CI = [0.215, 0.295]. Together, these results provided support for the hypothesized serial mediation model, which is illustrated in **Figure 2**.

Table 3. Regression analysis of variable relationships in the serial mediation model (Experiment 1)

Outcome variable	Predictor variable	$R$	$R^2$	$F$	$\beta$	$t$	$SE$	95%CI	
								Lower	Upper
Temporal perspective	Color	0.259	0.067	9.577**	-0.259	-3.095	0.084	-0.425	-0.093
	Arousal	0.519	0.269	48.939***	-0.519	-6.996	0.030	-0.266	-0.149
	Perceived temporal distance	0.736	0.541	156.997***	0.736	12.530	0.020	0.215	0.295
Arousal	Color	0.656	0.430	100.537***	0.656	10.027	0.164	1.316	1.963
Perceived temporal distance	Color	0.427	0.182	29.595***	-0.427	-5.440	0.226	-1.677	-0.783
	Arousal	0.752	0.565	172.961***	-0.752	-13.151	0.066	-0.998	-0.737

Note.  $\beta$  = Standardized Beta,  $SE$  = Standard Error. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

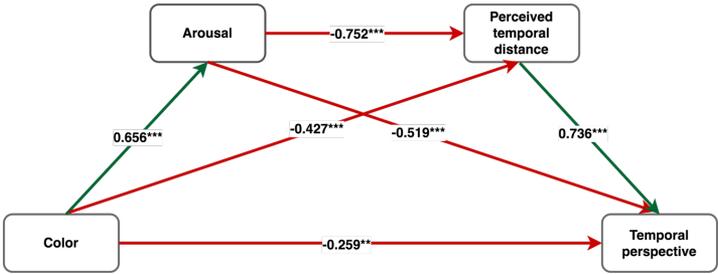


Figure 2. A serial mediation model of the relationship between color and temporal perspective through arousal and perceived temporal distance (Experiment 1). Standardized coefficients are displayed. Green lines indicate paths with positive associations. Red lines represent paths with negative associations. Note. \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

We then conducted single mediation analyses to examine the respective mediating roles of arousal and perceived temporal distance in the relationship between color and temporal perspective. Regressing temporal perspective on color when controlling for arousal revealed that only arousal,  $B = -0.245$ ,  $SE = 0.039$ ,  $p < 0.001$ , 95% CI = [-0.322, -0.167] but not color,  $B = -0.142$ ,  $SE = 0.098$ ,  $p =$

0.148, 95% CI = [-0.051, 0.336] was still significant, suggesting that arousal fully mediated the effect of color on temporal perspective. Similarly, regressing color and perceived temporal distance together on temporal perspective revealed that only the latter remained significant,  $B = 0.265$ ,  $SE = 0.023$ ,  $p < 0.001$ , 95% CI = [0.220, 0.309], suggesting that perceived temporal distance also played a fully mediating role in the color-time relationship.

Table 4. The direct and indirect effects of color on temporal perspective (Experiment 1)

Effect type	Path	Products of coefficients		Bootstrapped 95%CI	
		Effect	SE/BootSE	BootLLCI	BootULCI
Direct effect	Color → temporal perspective	1.841	0.936	0.007	3.675
Total indirect effect	Color → temporal perspective	-3.874	1.577	-7.331	-2.304
Indirect effect 1:	Color → Arousal → Temporal perspective	-0.167	0.809	-1.851	1.435
Indirect effect 2:	Color → Perceived temporal distance → Temporal perspective	1.017	0.949	-0.647	3.003
Indirect effect 3:	Color → Arousal → Perceived temporal distance → Temporal perspective	-4.725	1.796	-9.001	-3.103

Note. BootSE = Bootstrapped Standard Error, LL = Lower Limit, UL = Upper Limit.

Finally, to test the statistical robustness of the serial mediation model, we used the PORCESS Macro v.4.2 for SPSS (Model 6) (Hayes, 2018), with a 95% confidence interval (CI) that does not contain 0 indicating statistical significance. Displayed in **Table 4**, the bootstrap test results based on 5000 samples showed that arousal and perceived temporal distance serially and fully mediated the relationship between color and temporal perspective, as the direct effect of color on temporal perspective was no longer significant after controlling for the mediators (effect = 1.841,  $SE = 0.936$ , 95% CI = [0.007, 3.675]). More specifically, the total indirect effect of color on temporal perspective was -3.874,  $SE = 1.577$ , 95% CI = [-7.331, -2.304], which was composed of the indirect effects produced by three pathways: (1) color → arousal → temporal perspective (effect = -0.167,  $SE = 0.809$ , 95% CI = [-1.851, 1.435]); (2) color → perceived temporal distance → temporal perspective (effect = 1.017,  $SE = 0.949$ , 95% CI = [-0.647, 3.003]); and (3) color → arousal → perceived temporal distance → temporal perspective (effect = -4.725,  $SE = 1.796$ , 95% CI = [-9.001, -3.103]). Since the two mediators were measured very close in time, the order in which the mediators worked may be interchangeable (Wang, Jia, & Wang, 2024). To determine which one of the two mediators was essential

in explaining the association between color and temporal perspective, comparison pathways approach was adopted whereby the indirect pathway was initiated by perceived temporal distance followed by arousal (Walter, 2018). The results showed that reversing the order of the mediators rendered the serial mediation effect insignificant, as indicated by the 95% CI = [-0.676, 0.546] that includes 0.

Overall, Experiment 1 demonstrated that exposure to the “meeting” in red (vs. black) inclined participants toward the time-moving perspective, giving rise to a next *Monday* interpretation. The effect of red on the time-moving perspective was driven serially by heightened arousal and reduced perceived temporal distance. Notably, when considered in isolation, arousal and perceived temporal distance respectively and fully accounted for the observed effect. However, when tested jointly in the serial mediation model, the indirect pathway through either arousal or perceived temporal distance became no longer significant. This discrepancy, in conjunction with the significant serial pathway thus underscored the interdependent roles of the two mediators in the established association between red and the time-moving perspective and emphasized in particular that of the first mediator (i.e., arousal). We then designed another experiment to offer complementary evidence for the criticality of arousal in the red-time relationship.

## 2.2 Experiment 2

We followed the moderation-of-process design demonstrated in a previous study (Chan & Maglio, 2019) and tested the moderating role of arousal in the effect of red on the time-moving perspective. Specifically, we manipulated levels of arousal in a way independent from that of color and expected this alteration in arousal to moderate the said effect. If arousal was key in driving the effect, then accidentally intensifying arousal should enhance its strength by amplifying arousal evoked by red. Conversely, abating arousal should weaken its strength by diminishing red-evoked arousal.

### 2.2.1 Participants

*A priori* power analysis assuming a medium-sized effect ( $f = 0.25$ ) and 0.80 power at the alpha level of 0.05, with  $df = 3$  and 4 groups indicated that a minimum sample size of 179 was required. 238 students from a university in southwest China were recruited. None had participated in the foregoing experiment. They were assigned to the high arousal condition and low arousal condition in a random and equal manner. Within each condition, participants were subdivided into two groups (red vs. black). They were told that the aim of the experiment was to assess the suitability of the background music for student social gatherings. 4 participants in the high arousal condition and 2 participants in the low arousal condition did not fill out the questionnaire and therefore their data were excluded, leaving 115 samples

for the former condition (76 females,  $M_{\text{age}} = 21.50$  years,  $SD = 1.81$ ) and 117 for the latter (73 females,  $M_{\text{age}} = 21.87$  years,  $SD = 1.82$ ). There was no significant difference between the red group (81 females) and the black group (69 females) in age or gender ( $ps > 0.05$ ). All participants provided informed consent and each was monetarily compensated for their time.

### 2.2.2 Materials and procedure

The experiment was conducted in multimedia network digital language laboratories. Participants sat in individual cubicles. Each cubicle is equipped with a headphone and a desktop connected to the central computer at the teacher's desk, from which audio, video, and text content are shared. Based on one study outcome that fast (vs. slow)-tempo pop music induced greater arousal (Kim & Zauberman, 2019), we manipulated arousal using music of different tempi. Specifically, adapted from Kim and Zauberman's study (2019: Study 3), the pop song "*Across the Universe*" by the Beatles was chosen as the musical stimulus. A fast tempo has 120 to 168 beats per minute (BPM) and a slow tempo 76 to 108 BPM (Fernández-Sotos et al., 2016). Accordingly and using an online audio editor *123APPS*, we sped up the original tempo of the song (77 BPM) to 126.66 BPM for the high arousal condition and slowed it down to 88.93 BPM for the low arousal condition whilst retaining its original pitch.

To ensure the intended effect on arousal, we conducted a pre-test involving 70 participants, who listened to either the faster-tempo version ( $n = 34$ ) or the slower-tempo version ( $n = 36$ ). First, to check whether tempo alterations were successful, participants were asked to rate the tempo of the music on a 9-point Likert scale (1 = *very slow*"; "9 = *very fast*"). Then, participants reported how arousing they perceived the music to be according to the arousal dimension of the Self-Assessment Manikin, with "1 = *unaroused*" to "9 = *aroused*" (Bradley & Lang, 1994). They also rated how pleasant they found the music on the same scale ("1 = *very unpleasant*"; 9 = "*very pleasant*") to make sure that tempo manipulations impacted arousal without interfering with mood. The results showed that the fast-tempo version ( $M = 5.882$ ,  $SD = 0.946$ ) was judged to be significantly faster than its slower counterpart ( $M = 4.083$ ,  $SD = 0.841$ ),  $t(68) = -8.420$ ,  $p < 0.001$ ,  $d = -1.419$ , 95% CI = [-1.756, -1.083]. Importantly, participants perceived the fast-tempo music ( $M = 5.588$ ,  $SD = 1.373$ ) to be significantly more arousing than the slower version ( $M = 4.361$ ,  $SD = 1.457$ ),  $t(68) = -3.621$ ,  $p = 0.001$ ,  $d = -1.227$ , 95% CI = [-1.903, -0.551]. However, no significant difference was detected between the two regarding mood ( $M_{\text{fast}} = 4.255$ ,  $SD = 1.287$ ;  $M_{\text{slow}} = 3.971$ ,  $SD = 1.403$ ,  $p = 0.133$ ). Taken together, these results suggested that tempo manipulations exerted the sole effect on arousal as intended.

The music was played by the experimenter operating the central control at the teacher's desk but participants themselves can adjust the volume of the music to a personally comfortable level. The fast-tempo music was played for the high

arousal condition and the slow-tempo version for the low arousal condition. Participants first listened to the music for about two minutes before starting to fill a booklet of the questionnaire. The music continued on in the background until the completion of all the questions. Specifically, demographic information and informed consent were first provided. Then participants designated to the red group and the black group proceeded to resolve the binary “Next Wednesday’s meeting” question with the font colors of the word “meeting” correspondingly manipulated in the same way as was done in Experiment 1. As before, they subsequently reported current states of anxiety and anger, as well as feelings toward the meeting. To control for potential confounding music-related influences on temporal reasoning, participants subsequently evaluated the music itself in terms of familiarity and liking on an ascending 9-point Likert scale, with higher number indicating greater degree. Finally, two questions asking “What do you think of the genre of the music is” and “Would you pick this music as the background music for social gatherings for fellow students” were added to bolster the cover story.

### 2.2.3 Results and discussion

There was no significant difference between conditions regarding ratings of anxiety, anger, and subjective feelings toward the meeting. The same was true for those of familiarity and liking of the music (see **Table 5**). A factorial between-subjects 2 (arousal: high vs. low)  $\times$  2 (color: red vs. black) ANOVA was performed on the main and interaction effects of arousal and color on temporal perspectives. The results indicated that both the main effect of arousal,  $F(1, 228) = 7.548, p = 0.006, \eta_p^2 = 0.032$  and the main effect of color,  $F(1, 228) = 14.244, p < 0.001, \eta_p^2 = 0.059$  were significant. Between conditions, significantly more participants in the high arousal condition (84 out of 115 or 73.04%) answered *Monday* by taking the time-moving perspective than those in the low arousal condition (65 out of 117 or 55.56%),  $\chi^2_{1, 232} = 7.719, p = 0.005$ , Cramer’s  $V = 0.182$ , 95% CI = [0.005, 0.008]. Between groups, significantly more participants in the red group (88 out of 116 or 75.86%) adopted the time-moving perspective than those in the black group (61 out of 116 or 52.89%),  $\chi^2_{1, 232} = 13.676, p < 0.001$ , Cramer’s  $V = 0.243$ , 95% CI = [0.000, 0.001]. Crucially, the interaction between arousal and color was statistically significant,  $F(1, 228) = 4.525, p = 0.034, \eta_p^2 = 0.019$ . As illustrated in **Figure 3** and **Figure 4**, in the high arousal condition, participants in the red group were significantly more likely to take the time-moving perspective (54 *Mondays* vs. 6 *Fridays*) than those in the black group (30 *Mondays* vs. 25 *Fridays*),  $\chi^2_{1, 115} = 18.320, p < 0.001$ , Cramer’s  $V = 0.399$ , 95% CI = [0.000, 0.000]. Contrarily in the low arousal condition, the red “meeting” did not bias participants in favor of the time-moving perspective (34 *Mondays* vs. 22 *Fridays*) more than its black equivalent (33 *Mondays* vs. 28 *Fridays*),  $\chi^2_{1, 117} = 0.522, p = 0.470$ , Cramer’s  $V = 0.067$ , 95% CI = [0.557, 0.577].

Table 5. Descriptive statistics of anxiety, anger, subjective feelings, familiarity, and liking of the music and independent samples *t*-tests between the high arousal condition and the low arousal condition (Experiment 2)

Variable	High arousal condition	Low arousal condition	<i>t</i>	<i>p</i>	<i>d</i>	95% CI	
	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )				Lower	Upper
Anxiety	3.304 (1.778)	3.273 (1.851)	-0.129	0.897	-0.017	-0.276	0.242
Anger	2.539 (1.037)	2.350 (1.053)	-1.375	0.170	-0.180	-0.438	0.078
Subjective feelings	5.026 (1.501)	4.897 (1.528)	-0.647	0.518	-0.085	-0.344	0.174
Familiarity	2.070 (0.915)	2.248 (1.098)	1.343	0.181	0.176	-0.082	-.434
Liking	2.504 (0.842)	2.718 (1.265)	1.511	0.132	0.198	-0.060	0.456

Figure 3. Percentages of the time-moving perspective and the ego-moving perspective between the red group and the black group of the high arousal condition (Experiment 2).

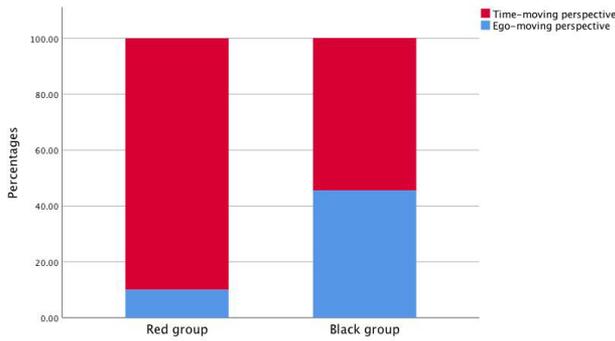
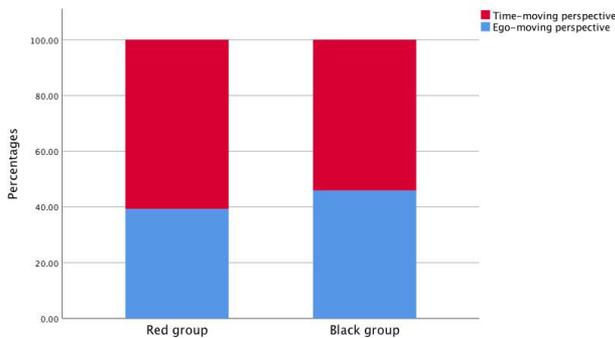


Figure 4. Percentages of the time-moving perspective and the ego-moving perspective between the red group and the black group of the low arousal condition (Experiment 2).



Taken together, these findings provided substantiating evidence for the predominant role of arousal in the association between red and the time-moving

perspective. Concretely, when arousal was kept at a high level, the effect of red on the preferred perspective on time remained strong. However, when arousal was subdued, as was the case in the low arousal condition where the arousal rating of the slow-tempo music averaged below the midpoint ( $M = 4.361$ ), the strength of this effect attenuated markedly in consequence.

### **3. General discussion**

#### **3.1 Overview**

The present research consisting of two experiments investigated the effect of red on temporal perspective preferences in the resolution of the ambiguous “Next Wednesday’s meeting” question and the underlying mechanism thereof. The current findings evinced an association between red and the time-moving perspective underlain sequentially by arousal and perceived temporal distance. Specifically, Experiment 1 showed that exposure to the word “meeting” in red (vs. black) font led to higher levels of arousal, which in turn reduced perceived temporal distance, aligning with the time-moving perspective whereby the event had been moved earlier to next *Monday*. To supplement evidence for the mediating role of arousal in the color-time link, Experiment 2 manipulated arousal in a way external to that of color. The results confirmed that arousal moderated the effect of color on the preferred perspective on time, such that red was associated with the time-moving perspective only under the condition of high arousal. Taken as a whole, these findings represent the first empirical demonstration of how visual perception in the way of color stimulus may affect the metaphorical construal of time through evoked arousal and the attendant variation in perceived temporal distance.

#### **3.2 Explanations**

##### **3.2.1 Red is arousing**

The color red has long been associated with arousal (Buechner & Maier, 2016; Wilson, 1966). In consistence with this existing association, we also found that a word styled with red font, relative to black, was perceived to be more arousing. Attribution of arousal to red may be rooted in red’s association with negative things which tend to be more arousing and salient than positive ones (Baumeister et al., 2001). Both specific and general conditioning help shape and consolidate the red-negativity association (Elliot & Maier, 2012). To elaborate, using a reaction time paradigm to assess basic color-valence associations, Moller

and collaborators (2009) found that failure-denoting words (e.g., wrong) were categorized significantly faster when colored in red than in green or white, evidencing a connection between red and failure. This red-failure link is the result of conditioning particular to the achievement context where red markings signify mistakes and inadequacies (Elliot & Maier, 2007). In more general terms, the color red typically conjures scenes and images of fire, blood, and danger and is therefore often exploited to communicate physical risk and hazard as displayed on warning signs and traffic signals (Gerend & Sias, 2009; Moller et al., 2009). Indeed, red is the single color most commonly linked to threat in public consciousness (Wogalter et al., 2002). Supporting this implicit association, a Stroop word evaluation task revealed that danger-related words (e.g., poison) displayed in red and danger-denoting symbols on red backgrounds were categorized significantly more quickly than green and grey equivalents (Pravossoudovitch et al., 2014). Consequently, repeated exposure to those red-negativity pairings contextualized and otherwise may well habituate people to the association between red and things of negative connotations. However, this reasoning does not seem to apply to our findings. Recall that in Experiment 1 the “meeting” in red scored higher on valence than the “meeting” in black. Given the latter’s average evaluative rating which approximates the midpoint ( $M = 5.045$ ), that of red should be considered positive in comparison. As an explanation, it is worth noting that although negative stimuli are more arousing than positive ones in general (Baumeister et al., 2001), emotional stimuli are more arousing than neutral ones irrespective of valence (Droit-Volet et al., 2004; Van Boven et al., 2010). Following the latter assertion, it is possible that the red “meeting” intensified arousal to a greater extent than the black one because compared to the emotionally neutral black, red was evaluated relatively positively.

### **3.2.2 Red is emotionally ambivalent**

On the other hand, the disparity in subjective feelings toward the “meeting” between the color conditions does not reach statistical significance, meaning that Mandarin speakers actually felt somewhat ambivalent about red’s emotional valence. To account for this culture-specific ambivalence, the color-in-context theory (Elliot & Maier, 2012) is worth considering. According to this account, the emotional significance associated with and the psychological effects consequent of a given color stimulus depends on the specificity of the context, which can be appetitive (positive) or aversive (negative) (Lang, 1995). With particular reference to the color red, whereas “a red-letter day” symbolizes celebration and evokes feelings of joy, “red tape” symbolizes bureaucracy and evokes feelings of annoyance. Empirically validating this emotional duality dictated by context, infants preferred a red paperboard to a green one after seeing a happy face (a positive context), but such preference was not present following the presentation of an angry face (a negative context) (Maier et al.,

2009). Similarly, whereas athletes wearing red sportswear performed better in sports contests (Maier et al., 2016), challenging intellectual tasks preceded by a glimpse of red impaired test performance (Elliot et al., 2007; Shi et al., 2015). That the red-valence association is context-specific thus allows for both positive and negative attributions to the color red, which is true for Chinese culture where red's positive connotation is particularly conspicuous. In support of this, a cross-national study of color meanings reported that in addition to words like "active" and "vibrant" agreed on by people from both Eastern (e.g., China) and Western cultures (e.g., the United States), the color red was also accorded the meaning of "pleasantness" by Chinese people (Madden et al., 2000). Additionally, influenced by the way stock market fluctuations in Chinese Mainland are color-coded, whereby an upmarket is displayed in red and a downmarket is displayed in green, participants from Chinese Mainland were more likely to predict greater growth in economy and consumption when the experimental stimuli were presented in red than in green, suggesting an implicit association between red and positivity (Jiang et al., 2014). Unlike the universal red-negativity pairing that originates from natural associations with blood and fire (Moller et al., 2009), the red-positivity correspondence is likely the product of socio-cultural assimilation. As a paradigmatic example, red is identified as a symbol of auspice, gracing such traditional paraphernalia and decorations as red envelopes and red couplets distinguishing the Spring Festival (Kawai et al., 2023; Wang et al., 2014). Corroborating red's emotional ambivalence subject to different underlying mechanisms, an inquiry into the emotional effects of red color on Chinese people found that participants responded to both positive and negative words faster than neutral ones followed by a red perceptual stimulus (Wang et al., 2014).

In light of the unspecified nature of the "meeting", it is logic to assume that any contextual cue arising from the "meeting" *per se* would be chiefly based on its distinguishing feature, that is, the font color. This assumption, coupled with Mandarin speakers' emotional ambivalence about red thus makes it possible for a simultaneous but conflicting activation of positive and negative associations, thereby rendering red's evaluation ambivalent. Moreover, although the finding that red was positively-valenced relative to black as observed in Experiment 1 disagrees with the red-negativity association recorded elsewhere (Elliot & Maier, 2007), it is nevertheless compatible with the color-in-context theory (Elliot & Maier, 2012). As noted earlier, the pairing of red and failure is specific to an achievement situation (Moller et al., 2009) and despite the inimical effect of red on intellectual performance being consistent regardless of the color stimulus being in a pictorial (Moller et al., 2009) or lexical form (Shi et al., 2015), as was the case here, the fact that metaphorical perspectives on time does not qualify as intellectual performance makes it possible for red to be decoupled from taking on a decidedly negative connotation particular to the achievement context.

### 3.2.3 High arousal leads to reduced perceived temporal distance

A few studies have shown that emotional arousal reduces psychological temporal distance (Van Boven et al., 2010; Xu et al., 2024). Concordant with this proposition, the present work also found that the higher-arousal red font led to a shorter perceived distance to the future than the lower-arousal black font. In particular, Experiment 2 showed that whilst the effect of red on the time-moving perspective remained robust when levels of arousal were maintained high, its strength considerably weakened as arousal was abated. Presumably, lowered arousal consequent of background music may have diminished the impact of red on perceived temporal distance and consequently temporal perspectives. These findings are consistent with previous ones which indicated that coffee cues facilitated concrete construal only at high levels of arousal, as attenuated arousal via video clips similarly dented the effect of coffee on psychological distance determining construal level (Chan & Maglio, 2019: Experiment 4)

The inverse relationship between arousal and psychological temporal distance may be accounted for by attention, which plays a key role in human timing behavior (Zakay & Block, 1996). According to the attentional-gate model, a pacemaker autonomously emits pulses at a pace influenced by arousal. When attention is focused on time, the attentional gate widens and allows more pulses to pass through to the cognitive counter where the total pulse count is recorded. When attention is directed away from time, the gate narrows and causes a decrement in pulses to be transmitted from the pacemaker to the counter (Politi et al., 2018; Zakay & Block, 1996). Because a person's attentional resources are divided between processing temporal information and any coincidental non-temporal information in a duration estimation task, attending to time amounts to longer estimates, whereas distraction aggregates shorter estimates.

Since attention devoted to stimuli external to time results in shorter time perception, it follows that stimuli that capture attention would likely achieve the same outcome. Inasmuch as highly arousing events divert attention away from peripheral information and toward central objects (Heuer & Reisberg, 1990), the more arousing the stimuli, the more attention they grab and hold (Zsidó, 2024). Of special relevance to the current research, previous study found that compared to unpleasant scenes presented in grayscale, the same images presented in color were perceived to be more arousing and biased attention in favor of task-irrelevant emotional information, therefore evidencing the facilitative role of color in enhancing emotional intensity and capturing attention in the visual processing of emotionally meaningful contents (Bekhtereva & Müller, 2017). Most pertinently, the arousing attribute of red makes it advantageous in attracting attention in both positive and negative-valenced contexts (Kuniewicz et al., 2015). Consequently, the more attention drawn to red would mean distraction from time and thereby result in shorter estimates. Crucially, time perception (perception of time that has elapsed)

and temporal distance judgement (perception of time that has yet to come) are positively linked, such that participants who overestimated durations also perceived the distance to the future to be longer (Kim & Zauberger, 2019). Together with the theorized shortening effect of red on time perception, it is plausible for red to exert the same effect on temporal distance judgement, resulting in shorter perceived temporal distance (in concordance with the time-moving perspective). However, the existing literature on the effect of red on time-perception has produced inconsistent results due to variation in, among other factors, color presentation modes, that is, as a background element or integrated into the task material (Hong et al., 2024). To provide supporting evidence for our reasoning, it is necessary for further research to test the proposed adverse effect of red on time perception, with red stimuli incorporated into the task instead of acting as the background color.

#### **3.2.4 Reduced perceived temporal distance maps onto the time-moving perspective**

Earlier work on the spatial conceptualization of time found that participants primed with an ego-moving spatial scenario tended to equate the “front” object to the one furthest away in a sequence of objects and accordingly interpret the meeting to be moved further down the line to next *Friday*. Conversely, when primed with a time-moving spatial scenario, participants tended to identify the “front” object as the one nearest to them in that sequence and consequently interpret the meeting to be moved ahead of time to next *Monday* (Boroditsky, 2000). These findings constitute first manifestation of conceptual mapping between spatial distance and temporal distance inherent in temporal perspectives. This association is corroborated by extended research demonstrating that factors via an embodied link to spatial distance can similarly affect temporal perspective preferences (Duffy & Feist, 2017; Matlock et al., 2005). For example, because the future appears less distant from the time-moving perspective than it does from the ego-moving perspective, the former perspective is associated with conscientiousness, attending to tasks without delay, whereas the latter is associated with procrastination, putting off tasks closer to the deadline (Duffy et al., 2014). Furthermore, a more distant perception of future, as is implied in the ego-moving perspective, makes the future less salient and therefore prioritizes the present. A closer such perception, on the other hand, as is implied in the time-moving perspective, makes the future stand out and privileges it accordingly (Crilly, 2017). Consequently, people preferring the time-moving perspective weighed future returns more heavily than those who favored the ego-moving perspective (Crilly, 2017), whilst those primed with the ego-moving (vs. time-moving) perspective perceived the future to be farther away and became more impatient in a waiting situation (Xu et al., 2024). Further attesting to the correspondence between perceived temporal distance and temporal perspectives, our findings suggested that red was linked to the time-moving perspective as a result of red shortening the perceived distance to the

future. The distance-perspective alignment means that factors that can modulate psychological distance may potentially influence temporal perspectives. For example, shifting from the observer perspective to the field perspective fosters a greater psychological distance (Gu & Tse, 2016). Whether doing so would lead to a propensity for the ego-moving perspective is worthy of further investigation.

### **3.3 Implications**

#### **3.3.1 Implications for color and psychological functioning**

Perception of red can impact performance on cognitive tasks (Elliot et al., 2007; Maier et al., 2008; Mehta & Zhu, 2009). Adding another cognitive corollary, we documented the novel effect of red on temporal conceptualization. Specifically, despite rich evidence indicating that red can cause time distortion (Hong et al., 2024), no research thus far has inquired into its influence on the metaphorical perspectives on time. Filling this gap, our findings provide first evidence associating red with the preference for the time-moving perspective in the resolution of the “Next Wednesday’s meeting” ambiguity. Notably, the detrimental effect of red on IQ test performance was ascribed to the perception of red prompting avoidance motivation (Maier et al., 2008), which is a prime manifestation of how color influences psychological functioning (Elliot & Maier, 2007). In a similar vein, the current research demonstrated that red impacted the time-moving perspective via heightened arousal and reduced psychological distance. As such, our work lays the foundation for further investigation into the potential effects other colors may have on temporal perspectives and the underlying psychological processes. For instance, previous research found that whereas red induced avoidance-underlain constriction of attention conducive to detail-oriented task performance, blue activated approach motivation beneficial for performance on a creativity task (Mehta & Zhu, 2009). Given that the ego-moving perspective is grounded in approach motivation (Hauser et al., 2009), it would be worth finding out whether perception of blue may facilitate psychological functioning associated with approach motivation and consequently promote the preference for ego-moving perspective.

#### **3.3.2 Implications for the sensory influence on temporal perspective preferences**

In addition to the multitude of human experiences, both spatial and somehow spatially grounded being uncovered as contributors to varying temporal perspective preferences (see Feist & Duffy, 2023 for a review), emerging lines of research have furnished evidence showing similar effects based on sensory stimuli. For example, Qin (2024a) found that when reasoning about the temporally ambiguous question, people who preferred spicy taste and those who actually consumed spicy

snacks were biased in favor of the ego-moving perspective. Similarly, a concurrent investigation into the effect of physical temperature on temporal reasoning showed that across both natural and artificial contexts, warm temperature evoked greater happiness, fostering an inclination toward the ego-moving perspective, whereas cold temperature evoked greater sadness, prompting an inclination toward the time-moving perspective (Qin, 2024b). Contributing complementary evidence along the same lines, our findings suggested that the visual perception of color can also modulate temporal perspective preferences. Further research may consider examining the potential effect of other sensory input on temporal reasoning. For instance, scents can evoke nostalgia, thus eliciting more positive emotion (Reid et al., 2015). In conjunction with the previously substantiated link between positive emotion and the ego-moving perspective (Zheng et al., 2019), it is possible that olfactory perception evocative of fond memories may relate to the ego-moving perspective through induced positive feelings. Future endeavors will do well to test this possibility.

### **3.4 Limitations**

The present study suffers from mainly three limitations, which may inform future research. First, the strength of color-meaning associations is subject to the relative salience of the emotional dimension (e.g., valence and arousal). Whereas red and green are polar opposites on the valence dimension (i.e., red-negative vs. green-positive), red is strongly opposed to blue (i.e., red-aggressive/enthusiastic vs. blue-calm) on the arousal dimension (Schietecat et al., 2018). Besides, emotional valence and arousal can independently and interactively influence perceived temporal distance (Mei et al., 2018). These insights and the fact that red was contrasted with neither color raise concern about the generalizability of the association between red and the time-moving perspective established herein. Therefore, future research may test its generalizability by contrasting the effect of “meeting” in red font with those of “meeting” in green and blue fonts, respectively on temporal reasoning.

Relatedly, any given color is rarely viewed as a standalone but experienced compositely in combination with other colors (Schloss & Palmer, 2011). For instance, red conjoining black is a signifier of felicity for Chinese people, as is clearly shown in their wedding invitations designed in the pattern of black lettering on a red background (Madden et al., 2000). In the current research, the color manipulation was achieved by styling the temporal event in question (i.e., “meeting”) in red font, leaving open whether red in combination with another color would exert the same impact on temporal perspective preferences as that of red alone. Future research may thus consider highlighting the “meeting” written in black in red and find out whether doing so would potentially tilt the red’s

emotional ambivalence observed herein toward a decidedly positive evaluation, since the evaluative valence would be derived from the color pairing instead of the individual color. Given the link between positive valence with the ego-moving perspective (Zheng et al., 2019), color manipulation thus done may tend toward a preference for the ego-moving perspective. Inquiries along these lines would contribute to a more refined understanding of how perceptual responses to colors affect metaphorical construal of time.

Finally and as mentioned earlier, red activates avoidance motivation and narrows the breadth of attention, undermining intellectual performance in consequence (Maier et al., 2008). Admittedly, examination of temporal perspective preference is not a test of performance attainment. Nevertheless, given the tighter coupling between avoidance motivation and the time-moving perspective (Margolies & Crawford, 2008), it would be amiss to discount entirely the possibility that the red font may have simultaneously motivated avoidance even in a circumstance that does not bear on achievement. Therefore, the alternative pathway through which red relates to the time-moving perspective via avoidance motivation merits further confirmation.

#### **4. Conclusion**

The current research documented the novel effect of color on people's temporal perspective preferences in the interpretation of the ambiguous "Next Wednesday's meeting" statement and shed light on its underlying mechanism. Specifically, we found that exposure to the "meeting" in red (vs. black) font led to the preference for the time-moving perspective and that this effect was serially mediated by heightened arousal and reduced perceived temporal distance. As such, our findings add to the multitude of factors influential in varying temporal perspective preferences and enrich the literature on color and psychological functioning (Elliot & Maier, 2007). Notably, the revelation that arousal is pivotal to the association between red and the time-moving perspective should be of great import, as theoretically factors that can affect arousal are capable of modulating perceived temporal distance and subsequently shaping metaphorical perspectives on time. Exploration of those factors promises to be a productive line of further inquiry.

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