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Temporal Doppler Effect and Future Orientation: Adaptive Function and Moderating Conditions

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Abstract

The objectives of this study were to examine whether the temporal Doppler effect exists in different time intervals and whether certain individual and environmental factors act as moderators of the effect. Using hierarchical linear modeling, we examined the existence of the temporal Doppler effect and the moderating effect of future orientation among 139 university students (Study 1), and then the moderating conditions of the temporal Doppler effect using two independent samples of 143 and 147 university students (Studies 2 and 3). Results indicated that the temporal Doppler effect existed in all of our studies, and that future orientation moderated the temporal Doppler effect. Further, time interval perception mediated the relationship between future orientation and the motivation to cope at long time intervals. Finally, positive affect was found to enhance the temporal Doppler effect, whereas control deprivation did not influence the effect. The temporal Doppler effect is moderated by the personality trait of future orientation and by the situational variable of experimentally manipulated positive affect. We have identified personality and environmental processes that could enhance the temporal Doppler effect, which could be valuable in cases where attention to a future task is necessary.

The Temporal Doppler Effect

The perception of time intervals can be affected by temporal orientation. Caruso, Van Boven, Chin, and Ward (2013) found evidence of a temporal effect in subjective time interval perception that is analogous to the Doppler effect in auditory perception. The Doppler effect is an asymmetry in the frequency of a wave produced by a moving object when a sound source approaches, passes, and recedes from an observer. For example, the sound wave emitted from a vehicle with a siren is received by the observer at a higher frequency during the vehicle's approach and at a lower frequency during its departure. In an analogous way, Caruso et al. (2013) found a systematic asymmetry whereby future events are perceived as being psychologically closer than are past events of equivalent objective temporal distance (e.g., 1week and 1 year).

This kind of asymmetry may have profound implications for individuals' adaptive functioning because it may enhance coping motivation toward future events. When individuals perceive a future event as being closer, especially a future goal they can strive for, they are more likely to invest effort and beproactive in learning to cope with impediments to goal attainment, for example, by being more vigilant (Löw, Lang, Smith, & Bradley, 2008), making more detailed plans (D'Argembeau, Renaud, & Martial, 2011), and preparing coping resources (Peetz, Wilson, & Strahan, 2009).

Caruso and colleagues (2013) suggested that the temporal Doppler effect is caused by one's future orientation. This speculation was never verified empirically, however. In this research, we aimed to test this hypothesis. We did so by comparing the temporal Doppler effect among persons with different levels of future orientation.

Future Orientation and Its Adaptive Function

The term *future orientation* has been used to refer to a collection of related affective, attitudinal, cognitive, and motivational constructs, in particular, a person's expectations about and actions related to the future (Nurmi, 1991). Future orientation has a potentially pervasive but largely ignored influence

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on much human behavior in regard to individuals' intention and action preferences (Zimbardo & Boyd, 1999). In this article, we focused on future orientation, where the aim is to reduce distant threats, meet current challenges, and foster personal growth (Aspinwall & Taylor, 1997; Schwarzer & Luszczynska, 2008).

Future orientation facilitates imagining of future goals and increases expectations of the actualization of these goals. This can result in enhancement of mental health (Webster, Bohlmeijer, & Westerhof, 2014).

Future orientation also has a protective function for individuals who have undergone stressful events in the past and been negatively affected by these events. If these individuals are led to shift their focus from the past onto the future, they are more likely to feel a sense of hope (Hassija, Luterek, Naragon-Gainey, Moore, & Simpson, 2012), confidence, or self-efficacy (Sword, Sword, Brunskill, & Zimbardo, 2013), thus being better able to recover from the stress than those who do not refocus. In addition, a focus on the future could help people build connections between past events and future goals, and induce adaptive self-reflection by affording people the cognitive means with which to reconcile past and future experiences (Boucher & Scoboria, 2014).

How do individuals fulfill the adaptive functions of future orientation? From our previous discussion, it can be inferred that having future orientation helps individuals to prepare for stressful events, leading to lower subjective temporal distance and resulting in a higher temporal Doppler effect. However, if this is so, future orientation should only predict an asymmetry for stressful events. In fact, we believe that it will also predict an asymmetry for single events where coping is not strictly necessary, such as planning to celebrate an upcoming Valentine's Day (Caruso et al., 2013).

Therefore, we reference Miller and Brickman's (2004) theory on future orientation and motivation, in which future orientation is defined as a tendency to attain valued future goals and has incentive value. Future goals were categorized as proximal subgoals and distant attainments, whereby individuals with high future orientation develop proximal goals on which they are willing to expend a great deal of effort to achieve in order to reach a distant goal. This makes their distant goal and proximal subgoals clearer, easier to visualize and access, and perceived as being closer.

The present studies explored the functional mechanisms of future orientation from the perspective of one's time interval perception of future versus past events. We infer that a high future orientation will magnify the temporal Doppler effect. We hypothesized a systematic asymmetry whereby future events are perceived as being psychologically closer than are past events of equivalent objective distance. We believe that future orientation will moderate the time interval perception of important stressful events, with high future orientation making individuals perceive an important future stressor as being closer, and a negative past stressor of equal objective time interval as farther away, thus demonstrating a temporal Doppler effect. Further, the perception of a shorter time interval demonstrated by high future orientation will help these individuals to invest more energy and resources to prepare for the future stressor and, therefore, will mediate the relationship between future orientation and coping motivation.

To achieve this goal, we modified the research paradigm used by Caruso et al. (2013) in the following four ways: First, given that the temporal Doppler effect may take different forms across short and long time intervals, we thought it important to sample a broader array of time intervals than Caruso et al., who sampled only 1 month and 1 year. Instead, we used six time intervals: 1 week, 2 weeks, 1 month, 3 months, 6 months, and 12 months. Second, we thought it important to examine individual differences in the hypothetical role of future orientation, a variable not included in previous research. Third, Caruso and colleagues used objective time intervals of 1 month and 1 year, along with a time point of Valentine's Day. However, we think that specifying a particular stressful event that will occur in the future (which needs to be prepared for in advance; e.g., an examination 2 weeks later) and a corresponding stressful event with unfavorable outcome from the past (e.g., having failed an examination 2 weeks ago) may be especially appropriate theoretically, and practically meaningful. Fourth, the 10-point rating of subjective time interval used by Caruso et al. may induce a more objective estimation of time interval, so we adopted the paradigm used by Peetz et al. (2009), in which participants drag a computer cursor along a line with an arrow to indicate the distance of the target event. We believe this operation may capture particularly well the psychological mechanism involved in subjective time interval perception.

Moderator Conditions of the Temporal Doppler Effect

Our second goal was to investigate conditions under which the temporal Doppler effect may be strengthened or diminished. In our second and third studies, we focused on the impact of positive emotion and control deprivation. Fredrickson & Branigan (2005) has proposed that positive affect has dual functions. Further, the impact of positive emotion on subjective estimation may be inferred in many respects. For instance, broadening is manifested by widening of attention scope, higher capacity for action, and more openness to new experiences (Raghunathan & Trope, 2002). Building helps individuals create and enhance social coping resources. Previous studies have shown that positive affect may attune individuals to their goals, thus promoting actions that direct them to the primary goals in their future (Gervey, Igou, & Trope, 2005). As another example, positive emotion can monopolize attention, thus shortening duration estimates (e.g., Sackett, Meyvis, Nelson, Converse, & Sackett, 2010).

We propose that the functions of broadening/building and attention driving of positive affect can be extended to the temporal perception domain, such that individuals with high positive affect are more capable of attending to future stressful events and reducing the time interval perception, thus demonstrating a stronger temporal Doppler effect, than individuals with low positive affect. It is hypothesized that this effect will be more salient for people with low future orientation because positive affect could compensate for the lack of motivation among those with low future orientation.

In contrast, we suggest that the temporal Doppler effect will be weakened in individuals who experience loss of control, especially for those with low future orientation. We base this prediction on locus of control theories, which claim that people will experience reduced motivation when perceiving a loss of control (Warburton, Williams, & Cairns, 2006). Previous studies have also shown that a low future orientation is related to less motivation to achieve future goals (Miller & Brickman, 2004), and that control deprivation leads people to be very careful and cautious when constructing an understanding of situations, including narrowing their temporal focus to the present rather than also considering the future (Pittman & D'Agostino, 1989). For example, when diagnosed with cancer, those with low future orientation will perceive a future event (e.g., a work duty or a festival) as being farther away. In addition, deprivation of control may induce negative affect, thus increasing future time interval perception. Therefore, if the past time interval perception remains unaffected, we predict that the temporal Doppler effect would weaken under the condition of control deprivation, especially among individuals with low future orientation.

Overview of the Present Studies

We sought to investigate an adaptive function of the temporal Doppler effect and to explore trait and situational conditions of the effect. Across three studies, we examined the interactive effect of future orientation and time frame (past vs. future), along with the three-way interactive effects of future orientation, time frame, and experimental priming for positive affect and control deprivation.

STUDY 1: THE MODERATING ROLE OF FUTURE ORIENTATION IN THE TEMPORAL DOPPLER EFFECT

Method

Participants. Chinese university students ($N = 139$; 62 men, 77 women) aged 17–28 years ($M = 19.75$, $SD = 1.98$) participated in the experiment.

Measures and Materials

Future Orientation Subscale of the Future-Oriented Coping Inventory for Youth. The Future Orientation (FO) subscale is from the Future-Oriented Coping Inventory for Youth (FCIY), which is based on the Consideration of Future Consequences Scale (CFC; Strathman, Gleicher, Boninger, & Edwards, 1994), Future Time Perspective Scale (FTP; Lang & Carstensen, 2002), and Temporal Focus Scale (TFS; Shipp, Edwards, & Lambert, 2009). In the Chinese cultural context, Wang, Yang, and Gan (2014) translated and revised the items and then performed exploratory and confirmatory factor analyses, which produced four dimensions, including FO, with satisfactory reliability and validity. The FO scale is an eight-item, self-administered questionnaire, and an example item is "I think it is important to perform a behavior with important distant consequences." Participants respond to each item using a 5-point scale that ranges from 1 (*strongly disagree*) to 5 (*strongly agree*). The internal consistency of the FO scale in this study was satisfactory, with a Cronbach's alpha of 0.77.

Academic Coping Motivation Inventory. The Academic Coping Motivation Inventory (ACMI) is a 10-item, self-administered questionnaire that was translated from Lockward, Jordan, and Kunda (2002). An example item is "I plan to put more time into my schoolwork." Participants respond to each item using a 7-point scale that ranges from 1 (*strongly disagree*) to 7 (*strongly agree*). As reported by Lockward et al. (2002), the ACMI demonstrated a one-dimensional factor structure. The internal consistency of the ACMI in this study was satisfactory, with a Cronbach's alpha of 0.76.

Temporal Axis Paradigm. A temporal axis paradigm developed by Peetz et al. (2009) was used to measure time interval perception. Participants locate the subjective time interval by dragging a computer cursor along an arrowed line of 13 cm from the present (left end for future events or right end for past events) to the moment of a particular event either in the future (arrow to the right) or in the past (arrow to the left). Appraisals of time interval were recorded using E-prime software (Schneider, Eschman, & Zuccolotto, 2002).

Participants were presented with six pairs of different stressful events that could occur in their academic life. Each pair appeared in a random order and comprised a future stressful event that the participant needed to cope with and a past event that was the negative outcome of the corresponding future event and was of equal objective distance (e.g., a coming examination in a week's time vs. failing an examination that was completed a week prior). The order of presentation of time frames (future vs. past) was counterbalanced across all subjects; that is, half of the participants completed the future framing task first, and the other half completed the past framing task first. Each trial used a combination of two of the following six time intervals: 1 week, 2 weeks, 1 month, 3 months, 6 months, and 12 months. In all six stressful events, there were two trials with different randomized time intervals (e.g., 1 week/1 month). An example of the instructions in the future time frame trial is as follows:

> Please complete the task about temporal perception. We are going to provide you with a series of future life events. Please perceive how far away this scenario seems to you from the present. You will be presented with a time axis with this moment as the starting point. Please drag your

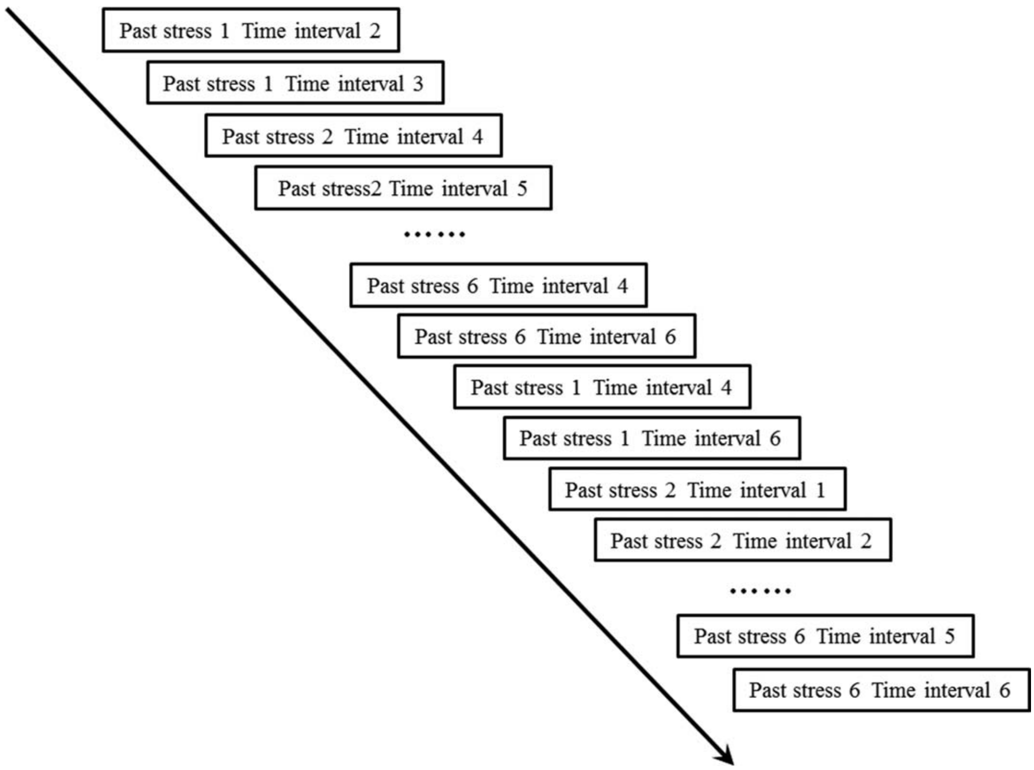

Figure 1 The task order used for the "past first" group.

> cursor to the right to a position that represents your subjective temporal difference from the starting point (on the left) to that particular event.

An example of the instructions in the past time frame trial is as follows:

> Please complete the task about temporal perception. We are going to provide you with a series of past life events. Please perceive how far away this scenario seems to you from the events to the present. You will be presented with a time axis with this moment as the starting point. Please drag your cursor to the left to a position that represents your subjective temporal difference from the starting point (on the right) to that particular event.

The task order used for the "past first" group is depicted in Figure 1. The distance from the left end (future events) or from the right end (past events) of the line to each participant's mark was recorded and used as an indicator of time interval perception. For each objective time interval, there were two future/past events, to which the participants responded one at a time, and the sum of these two values was regarded as their subjective time interval.

Procedures. The study protocol was approved by the Ethical Committee of the authors' academic institution. Informed consent was first obtained from all participants prior to their enrollment in the study. Then they were asked to complete the FO scale, the temporal axis task, and, finally, the ACMI. Participants were thanked and debriefed upon completion of the measures.

Results

The Temporal Doppler Effect. Our analysis was focused on occurrences of the temporal Doppler effect within future versus past time frames. Subjective temporal distances occurred within individuals, so multilevel modeling was used, and analyses were conducted using Mplus 7.0. (Muthén & Muthén, 1998).

To examine whether the data within individuals fit the hierarchical data structure, we used a null-hierarchical linear model to estimate the intraclass correlation coefficient (ICC) of subjective temporal distance. The data formed nested structures, and the ICC within individuals was 0.271. We then conducted analyses with subjective temporal distance as the within-group Level 1 variable and time frame (past = 0, future = 1) as the Level 1 independent variables. Because subjective temporal distance is strongly related to objective temporal distance (i.e., 1 week, 2 weeks, etc.), objective temporal distances were controlled for in the model. As shown in Table 1, when controlling for objective temporal distance, time frame had a main effect on the subjective temporal distance ($\beta = 0.545$, $p < .001$), which meant that the subjective temporal distance for the future event was

Table 1 Results for HLM Analysis of Future Orientation and Time Frame on Subjective Temporal Distance

Dependent Variable	Control Model			Model 1			Model 2		
STD	β	*SE*	95% CI	β	*SE*	95% CI	β	*SE*	95% CI
Main effect									
OTD	0.545***	0.029	[0.486, 0.603]	0.546***	0.029	[0.487, 0.604]	0.543***	0.030	[0.484, 0.601]
TF				−0.233***	0.035	[−0.303, −0.164]	−0.232***	0.034	[−0.298, −0.166]
FO				−0.001	0.992	[−0.160, 0.158]	0.183	0.103	[−0.018, 0.385]
Interactive effect									
FO × TF							−0.170***	0.046	[−0.260, −0.080]
R-square		0.297			0.353			0.377	
Chi-square		122.438			245.953			266.52	
df		1			3			4	
AIC		10565.004			10433.640			10397.173	
BIC		10586.710			10466.200			10435.158	

Note. HLM = hierarchical linear modeling; STD = subjective temporal distance; OTD = objective temporal distance; TF = time frame (0 = past; 1 = future); FO = future orientation; CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion.

evaluated as closer. The temporal Doppler effect was, thus, in existence.

The Moderating Effect of Future Orientation in the Temporal Doppler Effect. To examine the moderating effect of future orientation, additional models were built to examine the main effect of future orientation and the interaction effect between future orientation and time frame. The continuous variables (i.e., subjective temporal distance and future orientation) were centered across all individuals. Because time frame (past = 0, future = 1) was measured dichotomously, no centering was performed. With respect to effect size estimates and model fit, the R^2, chi-square, degrees of freedom (*df*), Akaike information criterion (AIC), and Bayesian information criterion (BIC) values are shown in Table 1. The main effect of future orientation on the temporal Doppler effect was nonsignificant ($\beta = 0.183$, $p = .075$). When the interaction term of future orientation and time frame was entered into the model, future orientation significantly moderated the temporal Doppler effect ($\beta = -0.170, p < .001$).

To gain insight into the simple relationship between future orientation and the temporal Doppler effect, we ran a simple slopes analysis to interpret the nature of the moderating effect. As shown in Figure 1, the temporal Doppler effect was stronger among individuals with high future orientation and completely absent among individuals with low future orientation.

The Mediating Effect of Subjective Temporal Distance in the Relationship Between Future Orientation and Coping Motivation. To test the mediating effect of subjective temporal distance in the relationship between future orientation and coping motivation, we used the bootstrapping procedure of Preacher and Hayes (2008) and the corresponding SPSS macro to test for indirect effects. We set the number of samples at 5,000 and used bias correction and the accelerated option. The results showed significant indirect effects of future orientation on coping motivation via the mediator of future subjective temporal distance at the time intervals of 3 months, $B = 0.071$, $SE = 0.040$, 95% CI [0.012, 0.180]; 6 months, $B = 0.081$, $SE = 0.045$, 95% CI [0.014, 0.198]; and 12 months, $B = 0.084$, $SE = 0.050$, 95% CI [0.001, 0.196]. The mediating effects of subjective temporal distance at the three short time intervals were nonsignificant.

Discussion

Three findings can be observed from Study 1. First, we confirmed that the temporal Doppler effect exists in all time intervals. Second, we identified the moderating effect of future orientation, wherein the temporal Doppler effect is stronger among individuals with high future orientation. Third, we found that future orientation had an impact on coping motivation via the mediator of subjective temporal distance at longer time intervals.

We designed different objective intervals and found that (a) the moderating effect of future orientation was stronger at longer time intervals, and (b) the mediating effect from future orientation to coping motivation exists only at longer time intervals. Previous research has found that at shorter time intervals, subjective temporal distance is proportional to objective temporal distance (Peetz et al., 2009); therefore, the Doppler effect is considered to be less functional due to the relatively small variance in the subjective temporal distance. In contrast, when the objective temporal distance lengthens, the subjective temporal distance is no longer in proportion. In this case, more individual differences (e.g., in future orientation) were reflected in the subjective temporal distance. Therefore, this effect is considered to be more functional at longer intervals, as subjective temporal distance mediates the relationship between future orientation and coping motivation.

However, could this short future orientation be compensated for by maintaining a high-level temporal Doppler effect, which has an important motivational function? In Study 2, we examined this effect by focusing on the situational factor of positive affect.

STUDY 2: THE MODERATING ROLES OF POSITIVE AFFECT AND FUTURE ORIENTATION IN THE TEMPORAL DOPPLER EFFECT

Method

Participants. Chinese university students (N = 143; 69 men, 74 women) aged 17 to 28 years (M = 19.78, SD = 1.93) participated in the experiment.

Measures and Materials. The FO scale and temporal axis paradigm were used, as in Study 1. In addition, as a manipulation task, we administered a portion of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The Positive Affect subscale contains 10 adjectives expressing positive emotional states. For the present study, we selected the three most commonly used words (*excited*, *active*, and *happy*) to measure positive feelings. Scale responses range from 1 (*none or a little*) to 10 (*very much*). The participants were instructed to rate their current feelings. The Cronbach's alpha for the Chinese version that we used in the current study was 0.80.

Procedures. Informed consent was first obtained from all participants prior to their enrollment in the study. Participants completed the PANAS twice, both before and after the affect priming.

First, they were asked to complete the FO scale and temporal axis task. Next, participants were randomly divided into one of the following two groups: positive affect priming (n = 75) and neutral priming (n = 68). In the positive affect priming condition, participants were instructed to spend approximately 1 minute recalling a recent experience that made them really happy, and to write down the details of the event (including its time and place, and who was involved). Then they were instructed to concentrate on their feelings about the event and to write them down in as much detail as possible. In the neutral priming condition, participants were instructed to spend approximately 1 minute recalling a recent typical weekday (from Monday to Friday), and to write down the details of the day in as detailed and objective a manner as possible, including the time and place of each activity, who was involved, and so on (Ziegler, 2013). Last, they were presented with the three manipulation check items and the temporal axis task. Participants were thanked and debriefed upon completion of these measures.

Results

Manipulation Check and Descriptive Statistics. A t-test comparing positive affect scores between positive emotion–primed and neutrally primed groups was conducted. Results showed a significantly higher level of positive affect after the positive emotion prime, $t(141) = 3.70$, $p = .0003$, Cohen's $d = 0.62$; positive emotion prime: $M = 16.00$, 95% CI [13.62, 17.36]; neutral prime: $M = 12.51$, 95% CI [11.29, 13.73].

Interactions Among Future Orientation, Affective Priming, and the Temporal Doppler Effect. On the basis of previous results on the moderating effect of future orientation, the interactions among future orientation, affective prime, and time frame were examined using hierarchical linear modeling (HLM). The ICC of subjective temporal distance was 0.246. As the variables of objective temporal distance and future orientation were measured continuously, whereas other variables were measured dichotomously, only continuous variables were centered across all individuals. We first used the objective temporal distance as the control variable ($\beta = 0.598$, $p < .001$) and examined the main effect of positive affective prime, future orientation, and time frame. Similar to Study 1, only time frame had a main effect on the outcome variable ($\beta_{\text{model-1}} = -0.205$, $p < .001$), and the main effects of the other two variables were nonsignificant, as shown in Table 2. When the interactions among all three variables were entered in the model, future orientation continued to moderate the temporal Doppler effect ($\beta_{\text{model-2}} = -0.067$, $p = .011$; $\beta_{\text{model-3}} = -0.127$, $p < .001$). Furthermore, the interaction among priming group, future orientation, and time frame was significant ($\beta = 0.085$, $p = .024$).

In order to interpret the three-way moderating effect of positive affect prime, future orientation, and time frame, we ran a simple slopes analysis, with time frame as the x-axis variable and future orientation and priming group as the moderating variables. As shown in Figure 2, the temporal Doppler effect was minimal among individuals with low future orientation in the neutral priming condition, but significantly magnified in the condition of positive affect priming.

Discussion

In Study 2, we replicated the moderating effect found in the control group of Study 1 and identified, using positive emotion priming, that the situational factor of positive affect interacts with this moderating effect, which supports our hypothesis. In the condition of positive emotion priming, the Doppler effect remained intact among individuals with high future orientation, and a very similar pattern was demonstrated for those with low future orientation.

Given that positive emotions can strengthen the Doppler effect, can any situational factors interact with future orientation and weaken this effect? Considering the motivational nature of the Doppler effect, we focused in Study 3 on control deprivation as a demoralization situational factor.

Table 2 Results for HLM Analysis of Affective Prime, Future Orientation, and Time Frame on Subjective Temporal Distance

Dependent Variable	Control Model			Model 1			Model 2			Model 3		
STD	β	*SE*	95% CI	β	*SE*	95% CI	β	*SE*	95% CI	β	*SE*	95% CI
Main Effect												
OTD	0.598***	0.016	[0.568, 0.629]	0.599***	0.015	[0.569, 0.629]	0.599***	0.015	[0.568, 0.629]	0.597***	0.016	[0.566, 0.628]
TF				—0.184***	0.019	[−0.221, −0.147]	−0.205***	0.027	[−0.258, −0.152]	−0.205***	0.027	[−0.258, −0.152]
FO				−0.191*	0.086	[−0.360, −0.023]	−0.119	0.128	[−0.371, 0.133]	−0.053	0.134	[−0.316, 0.210]
PA				−0.053	0.087	[−0.224, 0.119]	−0.087	0.093	[−0.270, 0.096]	−0.088	0.094	[−0.271, 0.096]
Interactive Effect												
FO × PA							0.004	0.076	[−0.146, 0.154]	−0.053	0.080	[−0.210, 0.105]
FO × TF							−0.067*	0.026	[−0.119, −0.015]	−0.127***	0.037	[−0.201, −0.054]
PA × TF							0.036	0.033	[−0.029, 0.101]	0.036	0.033	[−0.028, 0.101]
FO × PA × TF										0.085*	0.038	[0.011, 0.158]
R-square		0.358			0.393			0.397			0.402	
Chi-square		747.089			844.938			852.536			857.612	
df		1			4			7			8	
AIC		10641.381			10549.531			10547.934			10544.857	
BIC		10650.464			10565.427			10570.642			10569.837	

Note. HLM = hierarchical linear modeling; STD = subjective temporal distance; OTD = objective temporal distance; TF = time frame (0 = past; 1 = future); FO = future orientation; PA = positive affect; CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion.
$^{*}p < .05$. $^{***}p < .01$.

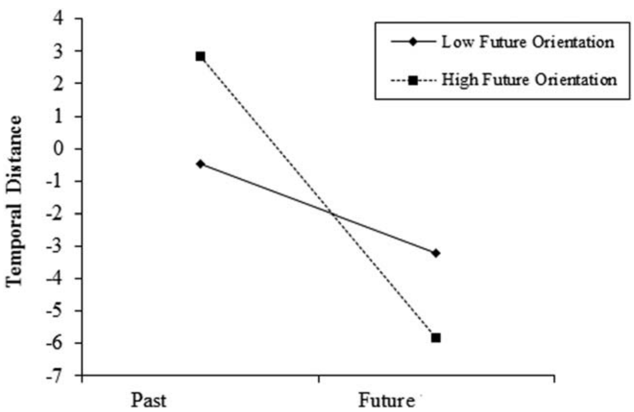

Figure 2 Interactional effects of future orientation and time frame on subjective temporal distances.

STUDY 3: THE MODERATING ROLES OF CONTROL DEPRIVATION AND FUTURE ORIENTATION IN THE TEMPORAL DOPPLER EFFECT

Method

Participants. Chinese university students ($N = 147$; 59 men, 88 women) aged 17 to 28 years ($M = 20.08$, $SD = 2.18$) participated in the experiment.

Measures and Materials. The FO scale and temporal axis paradigm were used, as in Study 1. In addition, a self-contrived four-item scale to assess sense of loss of control was applied as the manipulation check. An example item is "I felt that I had lost control of my life." Responses to this scale range from 1 (*none or a little*) to 5 (*very much*). The participants were instructed to rate their current feelings after the manipulation. The Cronbach's alpha for the Chinese version that was used in the current study was 0.71.

Procedures. Informed consent was first obtained from all participants prior to their enrollment in the study. Then they were asked to complete the FO scale and temporal axis task. Next, participants were randomly divided into one of the following two groups: control deprivation ($n = 74$) or neutral priming ($n = 73$).

Control deprivation was manipulated with a procedure used by Zhou, He, Yang, Lao, and Baumeister (2012). Participants were presented with pairs of figures that varied in five dimensions (different letters, uppercase or lowercase, red or black color, with dotted underline or with solid underline, and with circle frame or with square frame) and instructed to indicate which member of the pair belonged to a conceptual rule that had not been specified. Initial responses were, by necessity, guesses. In the control deprivation condition, participants were provided with feedback conveying that they were repeatedly failing to learn the classification. In the neutrally primed condition, participants did not get any feedback. Last, all participants filled out the four manipulation check items and the temporal axis task. Participants were thanked and debriefed upon completion of these measures.

Results

Reliability of Subjective Time Intervals. In two independent samples consisting of the two control groups in Studies 2 ($n = 68$) and 3 ($n = 73$), we found that at pretest and posttest, the test–retest reliability of items in the subjective time interval ranged from 0.73 to 0.87, suggesting a reasonably high level of replicability of the time axis paradigm.

Manipulation Check and Descriptive Statistics. A t-test comparing the sense of loss of control scores between control deprivation and neutral primed groups was conducted. Results showed a significantly higher sense of loss of control after the control deprivation prime, $t(145) = 3.34$, $p = 0.001$, Cohen's $d = 0.56$; control deprivation prime: $M = 12.73$, 95% CI [12.05, 13.41]; neutral prime: $M = 11.04$, 95% CI [10.29, 11.86].

Interactions Among Future Orientation, Control Deprivation Priming, and the Temporal Doppler Effect. Similar to the above analysis, we centered the continuous variables (i.e., temporal distance, future orientation) and used HLM (ICC = 0.124) to examine the main and moderating effects of control deprivation and future orientation. While controlling for objective temporal distance, we first ran the main effects model. As shown in Table 3, only time frame had a significant effect on temporal distance ($\beta = -0.184$, $p < .001$). Next, we attempted to replicate the interaction observed between future orientation and time frame in Studies 1 and 2, examining the interactions between future orientation and control deprivation, and between time frame and control deprivation. Future orientation significantly moderated the temporal Doppler effect ($\beta_{\text{model-2}} = 0.081$, $p = .011$; $\beta_{\text{model-3}} = -0.119$, $p < .001$), but the moderating effect of control deprivation was nonsignificant in regard to the temporal Doppler effect ($\beta = 0.038$, $p = .338$; shown in Table 3 and Figure 4). Last, the three-way interaction among priming group, future orientation, and time frame was also nonsignificant ($\beta = 0.056$, $p = .201$).

In order to interpret the moderating effect of future orientation on the temporal Doppler effect, we conducted a simple slopes analysis similar to that used in Study 2, with time frame as the x-axis variable. As shown in Figure 3, control deprivation prime had no effect on the temporal Doppler effect and did not interact with future orientation. Future orientation, as in Studies 1 and 2, moderated the temporal Doppler effect. In regard to the past time frame, future orientation did not significantly influence future subjective temporal distances. In contrast, in regard to the future time frame, individuals with higher future orientation perceived future events as being closer.

Table 3 Results for HLM Analysis of Control Deprivation Prime, Future Orientation, and Time Frame on Subjective Temporal Distances

Dependent Variable	Control Model			Model 1			Model 2			Model 3		
STD	β	*SE*	95% CI	β	*SE*	95% CI	β	*SE*	95% CI	β	*SE*	95% CI
Main Effect												
OTD	0.173***	0.016	[0.127, 0.219]	0.174***	0.022	[0.130, 0.218]	0.174***	0.022	[0.130, 0.217]	0.173***	0.022	[0.129, 0.216]
TF				−0.290***	0.022	[−0.333, −0.247]	−0.310***	0.032	[−0.373, −0.248]	−0.309***	0.032	[−0.371, −0.247]
FO				−0.101	0.101	[−0.299, 0.097]	0.150	0.149	[−0.142, 0.441]	0.212	0.154	[−0.089, 0.465]
CD				0.023	0.101	[−0.176, 0.222]	−0.032	0.116	[−0.260, 0.195]	−0.032	0.115	[−0.257, 0.193]
Interactive Effect												
FO × CD							−0.059	0.054	[−0.165, 0.047]	−0.096	0.062	[−0.218, 0.025]
FO × TF							−0.081*	0.032	[−0.143, −0.018]	−0.119***	0.043	[−0.204, −0.033]
CD × TF							0.038	0.039	[0.040, 0.115]	0.038	0.039	[−0.039, 0.115]
FO × CD × T										0.056	0.044	[−0.030, 0.142]
R-square		0.030			0.114			0.129			0.134	
Chi-square		52.578			208.599			217.096			218.75	
df		1			4			7			8	
AIC		13385.930			13235.907			13233.411			13233.757	
BIC		13395.013			13251.804			13256.119			13258.736	

Note. HLM = hierarchical linear modeling; STD = subjective temporal distance; OTD = objective temporal distance; TF = time frame (0 = past; 1 = future); FO = future orientation; CD = control deprivation; CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion.
$^{*}p < .05$. $^{***}p < .01$.

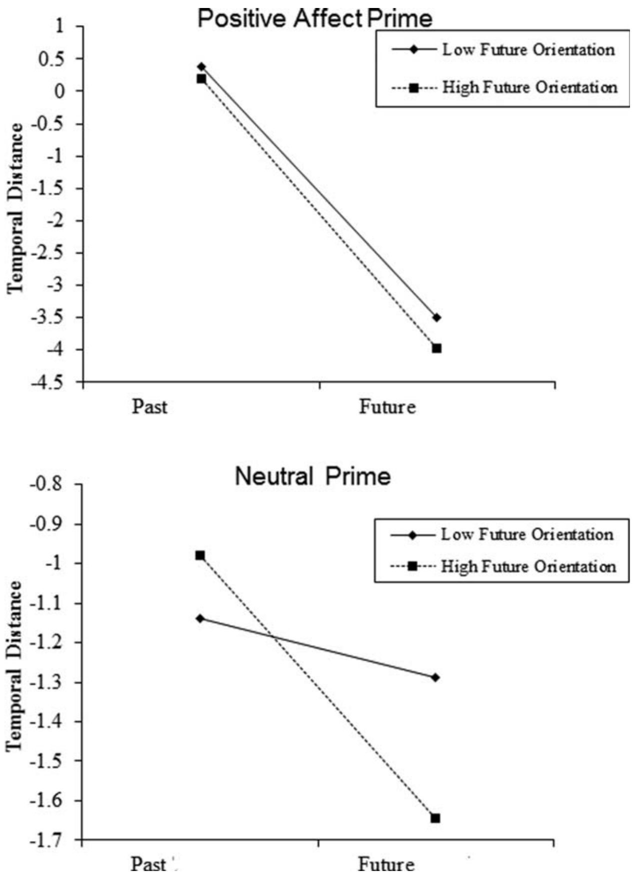

Figure 3 Interactional effects of affective priming, future orientation, and time frame on subjective temporal distances.

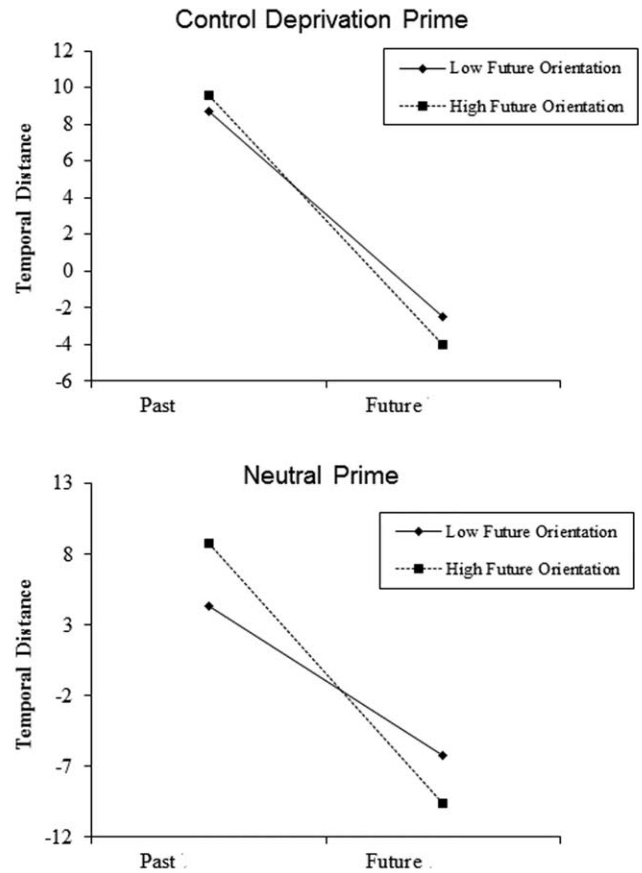

Figure 4 Interactional effects of control deprivation priming, future orientation, and time frame on subjective temporal distances.

Discussion

In Study 3, we again replicated the moderating effect in Study 1 and examined, via priming, control deprivation as another situational factor that may interact with this future orientation. The result failed to support our hypothesis; that is, control deprivation had no significant effect on the pattern of the interaction between future orientation and time frame. Given that our results ensured that the manipulation did work, this result cannot be attributed to a failure to induce control deprivation. However, irregular feedback might indicate that an individual repeatedly failed to learn the classification, thus eliciting a negative mood. As we cannot rule out this possibility, the priming effect should be viewed as a mixture of negative affect and control deprivation.

GENERAL DISCUSSION

In the present studies, we proposed and verified hypotheses that in the social cognition domain, the temporal Doppler effect is consistent across trait and situational conditions. Moreover, this temporal Doppler effect is moderated by an important personality trait of future orientation, and by a situational variable of experimentally manipulated positive affect. Positive affect strengthens the temporal Doppler effect among individuals with low future orientation. Our results further confirm the adaptive function of future orientation on the encouraging effect of motivation via a closer subjective temporal distance to future stressful events.

The three studies provided both direct and circumstantial evidence for the proposed hypotheses. The replicability of social cognitive experiments has been challenged in recent years (e.g., Funder et al., 2014; Klein et al., 2012), with the replicability of the time axis paradigm, in particular, being a key factor in determining the reliability of these studies. In Studies 2 and 3, we examined the test–retest reliability of the time axis paradigm using the two neutral priming groups, and our results support this form of reliability. The adequate sample size further ensured the power and, thus, the replicability of the results (Funder et al., 2014; Asendorpf et al., 2013). This also helped to ensure that findings that were nonsignificant were not the result of inadequate power.

The finding that the temporal Doppler effect is moderated by future orientation, which was replicated in all three studies, has rich theoretical and practical implications. The present results broaden our theoretical understanding of individual differences from the basis of the theory of future orientation and motivation. Specifically, by developing subgoals, individuals with high future orientation see distant stress as more proximal, so they put more effort into preparing to cope. These results are also important in bridging the lower and higher psychological processes.

Previous research has shown that high future orientation improved the time perspective abilities of individuals, enabling them to better foresee a future stressor (Gan et al., 2015).

This further explains the interaction among future orientation, temporal discounting, and task prioritization (Gan et al., 2015). The temporal Doppler effect appears to help people recategorize "important but not urgent tasks" to "important and urgent tasks," and thereby nonrational decision making is minimized. The reason for less subjective temporal distance is a time perspective ability possessed by high future-oriented copers (Gan, 2011). In other words, we have identified personality processes that could enhance the temporal Doppler effect, and that could be valuable in cases where attention to a future task is indeed urgently needed.

Positive affect acted as a moderating condition to the temporal Doppler effect for long time intervals, especially among individuals with low future orientation. In other words, the induction of positive affect has a protective role, allowing people who are low in future orientation to sustain the temporal Doppler effect, increasing their readiness to cope with future stressful events. This supported our hypothesis that the functions of broadening and building of positive affect (Gervey et al., 2005) could be extended to the temporal perception domain, and that positive experiences may cause underestimation of subjective time progression (Sackett et al., 2010).

Lee and Ji (2014) recently examined the influence of emotion valence on subjective temporal distance by differentiating between two time perspectives, namely, ego-moving and time-moving, to compare subjective temporal distance in four modes: pleasant past, unpleasant past, pleasant future, and unpleasant future. They found that subjective temporal distances were shorter in the two ego-moving perspectives (unpleasant past and pleasant future), and that emotion mediated the process of recalling the past and anticipating the future. The present study took a different perspective on past stressful events compared to future stressful events and the associated coping mechanisms, so our findings differ from those of Lee and Ji (2014) in that we identified the motivating process as being more functional in a subjective temporal distance context. This argument is consistent with past literature (see also Ross & Wilson, 2002; Zimbardo & Boyd, 1999). Consistent with Lee and Ji (2014), however, we found that positive emotion had a synergetic effect with motivation.

However, our hypothesis that control deprivation would weaken the temporal Doppler effect was not supported. This result may be explained as a mixed consequence of two oppositional effects. On the one hand, deprivation of control, or the accompanying effect of negative affect, may increase the future time interval perception, especially among individuals with low future orientation (Wakimoto, 2011), thus weakening the temporal Doppler effect. On the other hand, control deprivation may activate an abstract construal by overestimating time intervals of past stressful events, and, as a consequence, results in an enhanced temporal Doppler effect. In fact, we can observe longer subjective temporal distances in both past and future perception under the control deprivation condition among individuals with low future orientation. Our results in Study 3 provided detailed evidence for this explanation.

Dichotomizing continuous variables might be one alternative to the method used in the current study. However, in this research circumstance, we believe that the use of continuous variables and multilevel analyses is preferable (DeCoster, Iselin, & Gallucci, 2009) and constitutes a methodological advantage of the study.0

One limitation of the study is that all three studies were conducted among university students, and the 12 future/past pairs of stressful events were based on academic pressures that university students usually encounter. Further research is needed to generalize our conclusions regarding temporal Doppler effect to other populations. Another limitation is that we did not directly test subgoals in the mechanism to explain the relationship between future orientation and the temporal Doppler effect. Therefore, other explanations may also exist; for example, among those high in future orientation, future events may be more salient and consequences more vivid, or these individuals may be more optimistic in their expectations of success. In future research, we recommend considering the development of proximal subgoals as a mediating variable in the relationship between future orientation and the temporal Doppler effect to build solid evidence for this mechanism.

The present findings also provide implications for time management and stress intervention, offering a practical way to cope proactively in line with the saying "leave the bad times behind and a bright future awaits," which describes the function of the temporal Doppler effect. A distinguishable difference between human beings and animals is that humans are able to foresee and make efforts to plan for the future. Given the knowledge we have obtained in this research about the relationships among future orientation, positive affect, and subjective temporal distance, an intervention could be conducted to motivate people by helping them to move past previous failures and develop appropriate subgoals, in order to better prepare for and achieve their goals in the real world. A further estimation of future stressful events is one important reason that humans put things off; however, perceiving future stressful events as being closer is an effective way to overcome procrastination and become more productive. This capacity is valuable in modern society, where the ever-changing environment prevents considerable risk and frequent crises.

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