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Does Time Fly When You Engage More?

Effort Intensity Moderates the Relationship Between Affect and Time Perception

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Nikos L. D. Chatzisarantis was with Curtin University, Australia when the study was conducted. He was an internationally renowned researcher in the field of exercise and health psychology. Very sadly, he passed away in May 2020. His great contributions to the field are indelible.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Accessibility Statement

The datasets used and/or analyzed during the current study will be available from authors on reasonable request.

Abstract

The present study examined the hypothesis that effort intensity moderates the relationship between affect and time perception by employing more academic-related tasks and conditions. Two experiments were conducted to address the question. In Experiment 1, 139 adults (68 women; M_{age} = 23.7, *SD* = 3.2) were randomly assigned to one of six conditions (2 [time estimation paradigm] × 3 [task nature]) and worked on a computerized task for 6 minutes. In Experiment 2, 73 participants (35 women; M_{age} = 26.1, *SD* = 4.3) were randomly assigned to one of four conditions (2 ([time estimation paradigm] × 2 [task nature]) and completed both tasks for 6 minutes. Multiple moderator models were used to analyze multiple factors simultaneously in the data analysis for each experiment. Across two experiments, multiple moderator models revealed that a) enjoyment of the task was essential to perceive time passing faster regardless of different tasks and the effort level and b) the relationship between task enjoyment and the perceived speed of time was moderated by perceived effort. The findings of the study indicate that task nature and the effort level should be considered simultaneously to understand the relationship between task enjoyment and time perception in the ecologically valid situation.

Keywords: time perception; emotion; cognition; effort; moderation analysis

Does Time Fly When You Engage More?

Effort Intensity Moderates the Relationship Between Affect and Time Perception

Time is a subjective experience and one of the fundamental aspects of organisms' experiences. However, organisms' judgment about the passage of time is far from constant (Science Editor's Summary, 2016). For instance, time seems to fly when we are having fun and drags when we are bored (e.g., Droit-Volet & Meck, 2007). Previous studies suggested that the subjective experience of time is influenced by multiple factors such as emotions (Droit-Volet & Meck, 2007; Liu & Li, 2020; Uusberg et al., 2018), motivation (Gable & Poole, 2012; Gupta, 2022), attention (Coull et al., 2004), and arousal (e.g., Droit-Volet & Wearden, 2002).

To understand the central mechanism of variable time estimation, Soares et al. (2016) systematically investigated midbrain dopamine neurons during timing behavior in mice and found that dopamine neuron directly controlled the judgement of time. They proposed that dopaminergic activity may explain subjective time distortion which was observed in behavioral data.

Sackett et al. (2010) revealed that people's subjective enjoyment of an activity and their willingness to participate in the activity in future were improved simply by accelerating their perceived time progression. Considering that time perception is related to subjective well-being and motivation for future participation in the activity, it is important to understand the mechanisms of the association between affect and time perception in human behavior. To this end, Gable and Poole (2012) tested the relationship by incorporating the perspective of motivational direction and intensity, and found that time perception was shortened by high positive approach motivation.

Soares et al. (2016) proposed that flexibility in time estimation may provide individuals with adaptive advantage. For instance, shortening of time perception may lead to longer engagement in appetitive situations and enhance the possibility of obtaining appetitive rewards or goals (Gable & Poole, 2012; Soares et al., 2016). Given the possible benefits of shortening of time perception, it is significant to comprehensively understand how time perception is associated with affective and cognitive factors.

The Present Study

Motivation can be defined simply as the direction and energization of one's behavior (Elliot, 2006), and the second aspect of motivation is described as motivational intensity (e.g., Gable & Harmon-Jones, 2010; Gable & Poole 2012) or effort intensity (e.g., Gendolla et al., 2012). Gable and Poole (2012) found that time perception was shortened by high positive approach motivation. Based on their finding, it is suggested that intensity may modulate the association between affect and time perception.

One of weakness of the literature on the psychological time is that tasks used in experiments are often not ecologically valid in a real-life situation (Bisson et al., 2012; Tobin & Grondin, 2009). To enhance the control on the experimental situation, duration ranging from 100 ms to few seconds are commonly used in time estimation studies (Grondin, 2010). As Bisson et al. (2012) pointed out, the research findings drawn from non-ecological tasks might not be applied to other daily situations where time perception is involved. As stated earlier, time is a subjective experience and one of the fundamental aspects of organisms' experiences and influenced by multiple factors (e.g., emotions, motivation, and arousal). To comprehensively understand how time perception is associated with affective and cognitive interactions, it is critical to consider the multiple factors (emotions, tasks, motivation, and cognitive engagement) simultaneously in a study. Therefore, the present study aimed to

examine the hypothesis that effort intensity moderates the relationship between affect and time perception by employing different tasks (e.g., reading, a cognitive test) and conditions which are relevant and ecologically valid in education settings. Multiple moderator models (Hayes, 2013) were employed in the study to examine the hypothesis rigorously by including multiple factors simultaneously in each data analysis.

In the present study, two experiments were conducted in 2014 to examine whether effort moderates the relationship between affect and time perception. The study was approved by an institutional review committee and adhered to the guidelines for ethical practice.

Experiment 1

The first experiment aimed to examine how time perception is associated with affective and cognitive factors by using computerized tasks. According to the existing literature, it is known that interesting activities promote engagement (e.g., Jang et al., 2010). In Experiment 1, therefore, three different tasks were adopted to vary participants' interest in their assigned activities. Researchers on time estimation make a distinction between two paradigms: prospective and retrospective timing (Bisson et al., 2012; Grondin, 2001, 2010). In the former case, participants are informed before they perform the task that they will have to make a time-related judgment. In the latter case, they are told that they will have to do so only after they have completed the task (i.e., with no prior warning). Because time estimation is made at the same moment (i.e., once the task is over), the key difference between these two paradigm is that in the prospective paradigm, participants are aware that time is a critical component during the task, and therefore can allow more attentional resources to time (Bisson et al., 2012). Thus, prospective timing is related to attentional processes, and retrospective timing is mainly associated with memory processes. Block and Zakay (1997) reported that in general, prospective time estimates are longer and less variable than

retrospective time estimates. In the time estimation literature, there is a need for studies in which prospective and retrospective paradigms would be compared within the same task (Block & Zakay, 1997; Grondin, 2010). Therefore, both prospective and retrospective time estimations were used in Experiment 1 and compared across groups on the same task.

It was hypothesized that (a) the participants working on an interesting task would perceive higher enjoyment in the task and commit themselves to the task more intensively than those working on a boring or emotionally neutral task (H_1), (b) psychological time perceived by participants assigned to an interesting task would be shorter than that of the participants working on a boring or neutral task (H_2), and (c) there would be a synergy effect of engagement and enjoyment in predicting time perception (H_3). To examine the hypotheses, a 2 (time estimation paradigm) × 3 (task nature) between-subjects design was employed and there were six conditions in Experiment 1.

Method

Participants. A total of 139 adults (71 men, 68 women) aged 21-43 years (M = 23.7, SD = 3.2) voluntarily participated in the present study. They were university students and staff. Through preliminarily analyses, it was found that 37 participants out of 139 recruited participants provided unreasonable time estimations (e.g., total time was shorter or the same as minimum time). Therefore, they were excluded and the data from 102 participants (50 men, 52 women) aged 21-43 years (M = 23.6, SD = 3.3) were used for the subsequent data analyses. No significant difference was observed in participant's age and motivation for taking part in the experiment between included and excluded participants (age: t[136] = -.94, p = .347, d = .194; motivation: t[137] = 1.00, p = .318, d = .192).

A sample size of 102 participants was adequate to achieve a necessary statistical power. Based on a statistical power analysis conducted with the medium effect size of η_p^2

= .13 (f = .39) using G*Power version 3.1.9.4 (Faul et al., 2007), 92 participants were required to achieve a power of .80 at the alpha level of .05 (Cohen, 1992) for a 2 (time estimation paradigm) × 3 (task) factorial ANOVA.

Tasks. Three computerized tasks were created by the research team of the present study. The boring task was to move a ball from the left side of the screen to a target on the right side of the screen by using the right arrow key. The position of the target was fixed to the middle of the right side and the ball was moved from the middle of the left side and at a very slow constant speed. Once the ball reached the target, the ball was reset for a new session. The neutral task was also to move a ball from the left side of the screen to a target on the right side of the screen. However, the position of the target and the starting point of the ball were changed in each session. Thus, participants were required to change the direction of the ball towards the target by using the up, down, and right arrow keys. The ball was moved at a comfortable constant speed. The enjoyable task was to move a ball to the target in a maze. Although the starting point of the ball was fixed to the top left corner of the screen, the position of the target was changed in each session. Therefore, participants were required to change the direction of the ball towards the target by using the up, down, and right arrow keys. If the ball touched the black lines, it was returned to the start position on that session. The session was changed once the ball reached the target. The ball was moved at a comfortable constant speed.

Measures. Participants were asked to fill out a survey package that aimed to capture background information such as age and gender, motivation for participating in the experiment, interest in the assigned task, and their personal characteristics. The questionnaires on personal characteristics consisted of the Ten-Item Personality Inventory (Gosling et al., 2003, e.g., “I see myself as anxious, easily upset”); the General Causality

Orientations Scale (Deci & Ryan, 1985, e.g., "Whether there are good possibilities for advancement"); the Subjective Vitality Scale (Ryan & Federick, 1997, e.g., "I feel alive and vital"); the Satisfaction with Life Scale (Diener et al., 1985, e.g., "I am satisfied with my life"); the Positive Affect and Negative Affect Schedule (Watson et al., 1988, "To what extent you feel this way right now [e.g., irritable, determined, inspired"]).

After the completion of their assigned task, participants were asked a) to estimate the time of their activity (the length of the activity and the likely minimum and maximum duration of the activity) by indicating the number of minutes and seconds (Bisson et al., 2012) as well as b) to evaluate how they perceived the speed of time on a 10-point scale (1 = *very slow*, 10 = *very fast*). Then, they were asked how they found their activity on a 10-point scale (enjoyment: 1 = *very boring*, 10 = *very interesting*; difficulty: 1 = *very easy*, 10 = *very difficult*; stress: 1 = *not stressful at all*, 10 = *very stressful*). Finally, they were requested to fill out the Intrinsic Motivation Inventory (IMI; Ryan, 1982) to measure their subjective experience during their assigned task (e.g., "I tried very hard on this activity").

Procedure. Participants who were above 21 years old were recruited from a public university in Singapore. Once participants arrived at a laboratory, they were asked to fill out a consent form and a set of questionnaires. After obtaining informed consent, each participant was randomly assigned to one of the six conditions: 1) prospective – the boring task, 2) retrospective – the boring task, 3) prospective – the neutral task, 4) retrospective – the neutral simple task, 5) prospective – the enjoyable task, and 6) retrospective – the enjoyable task. Participants were subsequently asked to do a computerized task for 6 minutes. Participants assigned to retrospective timing started doing a specified task without a prior warning about time judgment. In the prospective condition, participants were told just before they start working on a task that they would have to estimate their working time after the activity. Each

task lasted for 6 minutes. On completion of the tasks, participants were briefed the purpose of the experiment and given a $5 voucher for their participation.

Data analyses. A 2 (time estimation paradigm) × 3 (task nature) between-subjects analysis of variance (ANOVA) was conducted on each time estimate index and task feedback variable. Partial eta-squared (η_p^2) was reported as a measure of effect size. Values of .02, .13, and .26 for η_p^2 indicate small, medium, and large effect sizes, respectively (Cohen, 1992). Furthermore, a moderation analysis was conducted with the SPSS version of the PROCESS macro (Version 2.16.3; Hayes, 2013) to examine the moderation effect of effort on the relationship between task enjoyment and psychological time.

Results

Manipulation checks. To examine the first hypothesis (H_1), a 2 (time estimation paradigm) × 3 (task nature) between-subjects ANOVA was conducted independently on perceived task enjoyment, difficulty, and stress scores as well as the IMI effort subscale score.

For perceived task enjoyment, the main effect of task nature was found significant, ($F[2,96] = 70.89$, $p < .001$, $\eta_p^2 = .60$). Bonferroni adjusted test ($p < .017$) revealed that the enjoyment score in the interesting task ($M = 8.17$, $SD = 1.75$) was significantly higher than that in the boring task ($M = 2.32$, $SD = 2.14$) and the neutral task ($M = 3.87$, $SD = 2.45$) (see Online Resource 1).

The main effect of time estimation paradigm and the interaction effect (task nature × time estimation paradigm) were found non-significant (time estimation paradigm: $F[1,96] = 0.10$, $p = .751$, $\eta_p^2 = .001$; interaction: $F[2,96] = 0.69$, $p = .503$, $\eta_p^2 = .014$). These results indicated that manipulation of the experiment tasks was successful. Similarly, the main effect of task nature was found only significant for perceived task difficulty and stress scores (task

difficulty: $F[2,96] = 26.71$, $p < .001$, $\eta_p^2 = .36$; task stress: $F[2,96] = 76.07$, $p < .001$, $\eta_p^2 = .61$). Bonferroni adjusted test ($p < .017$) for each score revealed that the perceived difficulty and stress scores in the interesting task (difficulty: $M = 5.75$, $SD = 2.22$; stress: $M = 4.67$, $SD = 2.66$) were significantly higher than those in the boring task (difficulty: $M = 1.35$, $SD = 1.01$; stress: $M = 1.85$, $SD = 1.73$) and the neutral task (difficulty: $M = 1.63$, $SD = 1.43$; stress: $M = 1.50$, $SD = 1.30$). These results indicated that compared to the boring and neutral tasks, the interesting task was perceived by participants not only more enjoyable but also more difficult and stressful.

For the IMI effort subscale score (Cronbach's $\alpha = .77$), the main effect of task nature was also found significant, ($F[2,96] = 16.56$, $p < .001$, $\eta_p^2 = .26$). Bonferroni adjusted test ($p < .017$) revealed that the effort score in the interesting task ($M = 4.74$, $SD = 1.23$) was significantly higher than that in the boring task ($M = 3.28$, $SD = 1.15$) and the neutral task ($M = 3.41$, $SD = 1.28$) (see Online Resource 2). The main effect of time estimation paradigm and the interaction effect (task nature × time estimation paradigm) were found non-significant (time estimation paradigm: $F[1,96] = 2.10$, $p = .150$, $\eta_p^2 = .021$; interaction: $F[2,96] = 1.44$, $p = .243$, $\eta_p^2 = .029$). These results indicated that participants working on the interesting task perceived that they put more effort into doing the task than the participants working on the boring and neutral tasks. Furthermore, Pearson's correlation analyses across the three tasks revealed that the effort score was significantly positively associated with perceived task enjoyment ($r = .46$, $p < .001$) and the perceived speed of time ($r = .36$, $p < .001$).

Time perception. To examine that psychological time perceived by participants assigned to an interesting task would be shorter than that of the participants working on a boring or neutral task (H_2), a 2 (time estimation paradigm) × 3 (task nature) between-subjects ANOVA was conducted on each of the time estimate variables. Based on Bisson et al.

(2012), three time-estimate dependent variables were used in analysis: (a) the estimated-to-target duration ratio and (b) the absolute standardized error, and (c) a Weber Fraction (WF)-like index. However, both main effects (task nature, time estimation paradigm) and the interaction effect (task nature × time estimation paradigm) were found non-significant for all the time estimate variables (i.e., the estimate-to-target ratio, the absolute standardized error, the WF-like index, the total time length, and the likely minimum/maximum duration). For the perceived speed of time, the main effect of task nature was found significant, (F[2,96] = 22.40, $p < .001$, $\eta_p^2 = .318$). Bonferroni adjusted test ($p < .017$) revealed that the perceived speed of time in the interesting task was significantly faster ($M = 6.39$, $SD = 2.48$) than that in the boring task ($M = 2.82$, $SD = 1.47$) and the neutral task ($M = 4.19$, $SD = 2.45$) (see Online Resource 3). The main effect of time estimation paradigm and the interaction effect (task nature × time estimation paradigm) were found non-significant (time estimation paradigm: F[1,96] = 0.002, $p = .963$, $\eta_p^2 = .000$; interaction: F[2,96] = 1.46, $p = .236$, $\eta_p^2 = .030$).

The moderation effect of effort. A moderation analysis was conducted to examine the moderation effect of effort on the relationship between task enjoyment and the speed of time. In doing so, task nature and perceived effort were entered as *multiple additive* moderators into a multiple moderator model (Hayes, 2013, see Figure 1) together with time estimation paradigm as a covariate. In this model, the interaction of task enjoyment and task nature was independent of perceived effort. When the variables were entered into the model, task nature and time estimation paradigm were dummy coded (the boring task = -1, the neutral task = 0, the interesting task = 1; prospective paradigm = -0.5, retrospective paradigm = 0.5) and the values of task enjoyment and perceived effort were centered. The equation of the multiple moderator model is described as follows:

$$\text{The Speed of Time} = \text{Intercept} + b_1\text{Enjoyment} + b_2\text{Task} + b_3\text{Effort} + b_4\text{Enjoyment*Task} + b_5\text{Enjoyment*Effort} + c_1\text{Paradigm}$$

In the equation, the regression coefficient b_1 estimates the conditional effect of task enjoyment on the perceived speed of time when both moderators (tasks nature and perceived effort) are at their averaged score (i.e., zero). The coefficient b_2 estimates the conditional effect of task nature on the perceived speed of time when task enjoyment and effort are zero, and the coefficient b_3 estimates the conditional effect of perceived effort on the perceived speed of time when task enjoyment and task nature are zero. Therefore, the regression coefficients b_2 and b_3 are not equivalent to main effects in ANOVA (Hayes, 2013). The regression coefficient b_4 quantifies how much the conditional effect of task enjoyment on the perceived speed of time changes as the value of task nature changes by one unit, holding the value of perceived effort constant, and b_5 estimates how much the conditional effect of task enjoyment on the perceived speed of time changes as the value of perceived effort by one unit, holding the value of task nature constant. Finally, the regression coefficient c_1 estimates the effect of time estimation paradigm on the perceived speed of time.

$$\text{The Speed of Time} = 4.443 + 0.511\text{Enjoyment} + 0.276\text{Task} + 0.085\text{Effort} + 0.170\text{Enjoyment*Task} - 0.114\text{Enjoyment*Effort} + 0.046\text{Paradigm}$$

The best fitting regression model was indicated above. The regression coefficient of task enjoyment was significant (b_1 = .511, 95% CI [.324, .697], t = 5.43, p < .001), indicating that there was a significant positive relationship between task enjoyment and the perceived speed of time when the values of task nature and perceived effort were their averaged scores (i.e., zero). Regression coefficients of task nature and perceived effort were found to be non-significant (task nature: b_2 = .276, 95% CI [-.304, .856], t = 0.95, p = .347; perceived effort:

b_3 = .085, 95% CI [-.256, .425], t = 0.50, p = .622), indicating that the two variables were not significantly related to the perceived speed of time when task enjoyment was zero while holding other variables constant.

However, both task nature and perceived effort were found to be significant moderators of the relationship between task enjoyment and the speed of time (enjoyment × task: b_4 = .170, 95% CI [.005, .335], t = 2.05, p = .044; enjoyment × perceived effort: b_5 = -.114, 95% CI [-.204, -.024], t = -2.51, p = .014). The two interaction terms as a set accounted for 3.56% of the variance in the perceived speed of time. Importantly, the moderation by perceived effort uniquely accounted for 2.85% of the variance $F(1,95) = 6.29$, p = .014, which was more than the variance explained by the moderation by tasks (1.60%), $F(1,95)$ = 4.19, p = .044. The coefficient of the covariate indicated that time estimation paradigm was not significantly related to the perceived speed of time (c_1 = .046, 95% CI [-.710, .801], t = .12, p = .904).

Figure 2 shows the conditional effect of task enjoyment on the perceived speed of time at the different levels of perceived effort. The relationship between task enjoyment and the perceived speed of time was consistently positive and statistically significant for all the tasks across different effort levels, except for the boring task at the high level of effort (b = .212, 95% CI [-.065, .488], t = 1.52, p = .132; see Experiment 1 in Table 1 and Figure 2c). Importantly, the coefficient of the interaction term of task enjoyment × perceived effort (b_5) was -.114, meaning that the conditional effect of task enjoyment on perceived speed of time changes by -.114 as perceived effort level increases by one unit, holding tasks constant. These findings from the multiple moderator model indicated that except for the boring task at the high level of effort, participants perceived that time passed faster as they found the task

was more enjoyable; however, the effect of task enjoyment on the perceived speed of time was diminished as the perceived effort level increased.

Discussion

Compared to the participants working on the boring and neutral tasks, the participants working on the interesting task perceived that a) their assigned task was more enjoyable and they put more effort in doing the task (H_1) and b) time passed significantly faster (H_2). Furthermore, the relationship between task enjoyment and perceived speed of time was moderated by perceived effort. This finding supported a synergy effect of engagement and enjoyment in predicting time perception (H_3). The first and second hypotheses were tested through the between-subjects ANOVAs. As expected, the scores of enjoyment, effort, and perceived speed of time in the interesting task were significantly different from the score in the neutral and boring tasks. However, a significant difference in the scores of enjoyment, effort, and perceived speed of time were not expected between the neutral and boring tasks as it was not a focus of the present study. The non-significant difference in enjoyment, effort, and perceived speed of time between neutral and boring tasks in the between-subjects ANOVAs do not undermine the support for the third hypothesis since task nature was dummy coded in the multiple moderation analysis to contrast the effect of task nature on the relationship between task enjoyment and the perceived speed of time.

Experiment 2

The second experiment aimed to cross-examine the findings from Experiment 1 by using different tasks. Reading and computer game tasks have been used as more ecological tasks in the literature (e.g., Bisson et al., 2012; Tobin & Grondin, 2009). Compared to the tasks in Experiment 1, more academic-related tasks such as reading and a cognitive test were

employed in Experiment 2. The reading and cognitive test tasks were selected as they were also self-paced and non-self-paced tasks, respectively.

It was hypothesized that despite the difference in the assigned task nature between Experiments 1 and 2, a) the perceived speed of time would be positively associated with task enjoyment (H_4) and b) the relationship between task enjoyment and perceived speed of time would be moderated by perceived effort (H_5).[1] To examine the hypotheses, a 2 (time estimation paradigm) × 2 (task nature) mixed design was employed and therefore there were four conditions in Experiment 2.

Method

Participants. A total of 73 adults (38 men, 35 women) aged 21-44 years (M = 26.1, SD = 4.3) were recruited and randomly assigned to one of the four conditions. Participants were university students and staff. Based on a statistical power analysis conducted the medium effect size of $\eta_p^2 = .13$ ($f = .39$), 56 participants were required to achieve a power of .80 at the alpha level of .05 (Cohen, 1992) for a 2 (time estimation paradigm) × 2 (task) mixed ANOVA.

Tasks. Participants were requested to read an article titled "20 things you need to know about Einstein" for the reading task and do computerized Stroop test (Stroop, 1935) for the cognitive test task. The computerized Stroop Word-Color test was conducted by using Inquisit 4 (Millisecond Software, 2014). Participants completed both tasks (reading and cognitive test) for 6 minutes each and the order of the two tasks was counterbalanced (reading → cognitive test or cognitive test → reading).[2] Participants were instructed to read the article at their own pace in the reading task, whereas they were requested to respond to a stimulus appeared on the computer screen as soon as possible in the cognitive test task.

Measures. In Experiment 2, the same measures as Experiment 1 were used except for one of measures. The Achievement Goal Questionnaire-Revised (Elliot & Maruyama, 2008, e.g., "My goal is to learn as much as possible.") was used in Experiment 2 instead of the General Causality Orientations Scale (Deci & Ryan, 1985).

Procedure. The same procedures as Experiment 1 were used for Experiment 2, except for the tasks and one of questionnaires. Participants who were above 21 years old were recruited from the same public university in Singapore. After obtaining informed consent, each participant was randomly assigned to one of the four conditions: 1) prospective – the reading task, 2) retrospective – the reading task, 3) prospective – the cognitive test task, and 4) retrospective – the cognitive test task. Participants were requested to do both tasks. Participants assigned to retrospective timing started doing a specified task without a prior warning about time judgment. In the prospective condition, participants were told just before they start working on a task that they would have to estimate their working time after the activity. Each task lasted for 6 minutes. On completion of the tasks, participants were briefed the purpose of the experiment and given a $5 voucher for their participation.

Results

Preliminary analyses indicated that there was no significant difference between time estimation paradigm (prospective vs. retrospective) for background and personality variables. A 2 (time estimation paradigm) × 2 (task nature) mixed ANOVA was conducted independently on perceived task enjoyment, difficulty, and stress scores as well as the IMI effort subscale score.

The main effect of task nature was found significant for enjoyment, stress, and effort score (task enjoyment: $F[1,71] = 7.95$, $p = .006$, $\eta_p^2 = .10$; task stress: $F[1,71] = 38.13$, $p < .001$, $\eta_p^2 = .35$; the IMI effort: $F[1,71] = 27.23$, $p < .001$, $\eta_p^2 = .28$). The enjoyment score in

the reading task (M = 7.14, SD = 2.63) was found significantly higher than that in the cognitive test task (M = 5.97, SD = 2.48), whereas the stress score in the reading task (M = 3.59, SD = 2.55) was significantly lower than that in the cognitive test task (M = 5.49, SD = 2.39). For the IMI effort subscale score (Cronbach's α = .75), the effort in the reading task (M = 4.28, SD = 1.02) was significantly lower than that in the cognitive test task (M = 5.02, SD = 1.04). Pearson's correlation analyses across the two tasks indicated that the effort score was significantly positively associated with perceived task enjoyment (r = .18, p = .034) but not directly related to the perceived speed of time (r = -.01, p = .902).

For the perceived speed of time, the main effect of task nature was found significant, (F[1,71] = 6.97, p = .01, η_p^2 = .089). The perceived speed of time in the reading task was significantly faster (M = 5.96, SD = 2.44) than that in the cognitive test task (M = 4.94, SD = 2.60). The main effect of time estimation paradigm and the interaction effect (task nature × time estimation paradigm) were found non-significant (time estimation paradigm: F[1,71] = 0.51, p = .480, η_p^2 = .007; interaction: F[1,71] = 2.11, p = .151, η_p^2 = .029).

A moderation analysis was conducted to examine the moderation effect of effort on the relationship between task enjoyment and the speed of time. Task nature and perceived effort were entered as moderators into a multiple moderator model (Hayes, 2013; see Figure 1) together with time estimation paradigm and the order of the two tasks as covariates. The equation of the multiple moderator model is described as follows:

$$\text{The Speed of Time} = \text{Intercept} + b_1\text{Enjoyment} + b_2\text{Task} + b_3\text{Effort} + b_4\text{Enjoyment*Task} + b_5\text{Enjoyment*Effort} + c_1\text{Paradigm} + c_2\text{Task Order}$$

When the variables were entered into the model, task nature, time estimation paradigm, and the order of the tasks were dummy coded (the reading task = - 0.5, the cognitive test = 0.5;

prospective paradigm = - 0.5, retrospective paradigm = 0.5; reading → cognitive test = - 0.5, cognitive test → reading = 0.5) and the values of task enjoyment and perceived effort were centered. The best fitting regression model was below.

The Speed of Time = 5.440 + 0.602Enjoyment - 0.163Task - 0.169Effort
- 0.218Enjoyment*Task + 0.143Enjoyment*Effort - 0.052Paradigm
+ 0.233Task Order

The regression coefficient of task enjoyment was significant (b_1 = .602, 95% CI [.438, .767], t = 7.24, p = < .001), indicating that there was a significant positive relationship between task enjoyment and the perceived speed of time when the values of task nature and perceived effort were their averaged scores (i.e., zero). Regression coefficients of task and perceived effort were found to be non-significant (task: b_2 = - 0.163, 95% CI [-1.043, .718], t = -0.37, p = .715; perceived effort: b_3 = - 0.163, 95% CI [-.573, .234], t = -0.83, p = .408), indicating that the two variables were not significantly associated with the perceived speed of time when task enjoyment was zero while holding other variables constant.

Although task nature was not a significant moderator (enjoyment × tasks: b_4 = -.218, 95% CI [-.104, .540], t = 1.34, p = .184), perceived effort was found to be a significant moderator of the effect of task enjoyment on the perceived speed of time (enjoyment × perceived effort: b_5 = .144, 95% CI [.018, .270], t = 2.26, p = .026). The moderation by perceived effort uniquely accounted for 2.56% of the variance $F(1,138)$ = 5.09, p = .026. Neither of the covariates was significantly related to the perceived speed of time (time estimation paradigm: c_1 = -.052, 95% CI [-.771, .667], t = -.14, p = .886; the order of the tasks: c_2 = .233, 95% CI [-.443, .907], t = .68, p = .497).

Figure 3 shows the conditional effect of task enjoyment on the perceived speed of time at the different levels of perceived effort. The relationship between task enjoyment and

the perceived speed of time was consistently positive and statistically significant for both the tasks across different effort levels (see Experiment 2 in Table 1). Importantly, the coefficient of the interaction term of task enjoyment × perceived effort (b_5) was .144, meaning that the conditional effect of task enjoyment on perceived speed of time changes by .144 as perceived effort level increases by one unit, holding tasks constant. These findings from the multiple moderator model indicated that participants perceived that time passed faster as they found the task was more enjoyable and the effect of task enjoyment on the perceived speed of time was enhanced as the perceived effort level increased.

Discussion

Despite the difference in the assigned tasks between Experiments 1 and 2, a) the perceived speed of time was positively associated with task enjoyment (H_4) and b) the relationship between task enjoyment and perceived speed of time was moderated by perceived effort (H_5). Unlike the finding of Experiment 1, however, the positive relationship between task enjoyment and the perceived speed of time was found to be enhanced as the perceived effort level increased.

General Discussion

The present experiments were conducted to examine whether effort moderates the relationship between affect and time perception for comprehensively understanding how time perception is associated with affective and cognitive interactions. One of weakness of the existing literature on the psychological time is that tasks used in experiments are often not ecologically valid in a real-life situation (Bisson et al., 2012; Tobin & Grondin, 2009). Thus, tasks (reading and cognitive test) and conditions which are relevant and ecologically valid in education settings were employed in the two experiments.

Across two experiments, multiple moderator models consistently revealed that a) task enjoyment was significantly positively associated with the perceived speed of time when the values of task nature and perceived effort were their averaged scores (i.e., zero) and b) task nature and perceived effort were not related to the perceived speed of time when task enjoyment was zero while holding other variables constant. These consistent results strongly supported the notions that people perceive time faster when they enjoy the activity and that task enjoyment is essential to perceive the speed of time faster.

Results of moderation analyses also revealed that perceived effort was the significant moderator on the relationship between task enjoyment and the perceived speed of time in the additive multiple moderator model in Experiments 1 and 2. However, the multiple moderator models in Experiments 1 and 2 revealed that the moderation effect of perceived effort on the relationship between task enjoyment and the perceived speed of time was in the opposite direction between Experiments 1 and 2. As the perceived effort level increased, the effect of task enjoyment on the perceived speed of time was diminished in Experiment 1 but enhanced in Experiment 2. This interesting result might be related to difference in the task enjoyment level between Experiments 1 and 2. In Experiment 1, task enjoyment scores were as follows: the boring task (M = 2.32, SD = 2.14), and the neutral task (M = 3.87, SD = 2.45), and the interesting task (M = 8.17, SD = 1.75). More than half of participants (64.7%) took part in boring or neutral task, and their task enjoyment scores were between 2 and 4 out of the 10-point scale. On the other hand, the enjoyment scores in Experiment 2 were much higher: the reading task (M = 7.14, SD = 2.63) and the cognitive test task (M = 5.97, SD = 2.48). These results suggest that putting effort in low-enjoyment-level tasks might attenuate the relationship between task enjoyment and the perceived speed of time, whereas putting effort in high-enjoyment-level tasks might enhance the association. Thus, it is critical to consider

task nature and the effort level simultaneously for understanding the association between task enjoyment and time perception in the ecologically valid situation.

There are several limitations to the present study. One of those is the fact that time estimation paradigm was not significantly related to the perceived speed of time, whereas both prospective and retrospective time estimation paradigms were used in Experiments 1 and 2 and their effects were compared. Perhaps, mentioning to participants just before working on a task the fact that they would be asked for a time estimate was not sufficient to produce a systematic shift in the amount of attentional resources to time during the experimental task (Matthews & Meck, 2014).

Another limitation is that only one target time duration was used in the present study, following previous studies (e.g., Bisson et al., 2012). However, time estimation processes might vary due to durations (Grondin, 2001). Thus, the present findings might not be generalized until replication studies are conducted by employing other durations. Furthermore, reading and a computerized cognitive test were used as academic-related tasks in the current study. Other ecologically valid academic-related tasks, such as writing and math tests, could be used in future studies.

Conclusion

The subjective experience of time is influenced by multiple factors (e.g., emotions, tasks, motivation, and cognitive engagement). To comprehensively understand how time perception is associated with affective and cognitive interactions, it is critical to consider the multiple factors simultaneously by using ecologically valid tasks. In the present study, we examined the hypothesis that effort intensity moderates the relationship between affect and time perception by employing tasks and conditions which are relevant and ecologically valid in education settings. The current experiments consistently demonstrated that a) enjoyment of

the task was essential to perceive time passing faster regardless of different tasks and the effort level and b) the relationship between task enjoyment and the perceived speed of time was moderated by perceived effort. In the present study, the results of two experiments suggested that putting effort in low-enjoyment-level tasks might attenuate the relationship between task enjoyment and the perceived speed of time, whereas putting effort in high-enjoyment-level tasks might enhance the association. The findings have important practical implications, given that individual's motivation for future participation in the activity is enhanced by accelerating their perceived time progression (Sackett et al., 2010). For example, it is critical for educators to maintain adequate level of enjoyable components in learning tasks and to devise suitable approaches to reduce learners' perceived effort level when they work on less enjoyable tasks.

Footnotes

[1] Based on the results of Experiment 1, Experiment 2 focused on the perceived speed of time.

[2] Participants assigned to the retrospective timing condition (n = 37) would know that after completing the first task, they were going to be asked to estimate time in the second task. For both of reading and cognitive tasks, the perceived speed of time were similar between the two groups with the different task order (Group 1: reading → cognitive test; Group 2: cognitive test → reading): reading: M = 5.44, SD = 2.6 for Group 1, M = 6.21, SD = 2.8 for Group 2; cognitive test: M = 5.67, SD = 2.6 for Group 1, M = 5.11, SD = 2.9 for Group 2). For both tasks, no significant difference was observed in the perceived speed of time between the two groups (reading: t[35] = -.86, p = .395; cognitive test: t[35] = .61, p = .544).

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Table 1

Conditional Effect of Enjoyment on Speed of Time at Values of Moderators (Effort and Task)

Effort	Task	CE	*SE*	*t*	*p*	95% CI Lower, Upper
Experiment 1						
Low	Boring	.527	.120	4.383	.000	.288, .765
	Neutral	.668	.108	6.187	.000	.454, .883
	Interesting	.810	.136	5.960	.000	.540, 1.080
Middle	Boring	.369	.114	3.244	.002	.143, .595
	Neutral	.511	.094	5.429	.000	.324, .697
	Interesting	.652	.120	5.451	.000	.415, .890
High	Boring	.212	.139	1.521	.132	-.065, .488
	Neutral	.353	.118	2.993	.004	.119, .588
	Interesting	.495	.134	3.680	.000	.228, .762
Experiment 2						
Low	Cognitive Test	.555	.133	4.166	.000	.291, .818
	Reading	.337	.099	3.410	.001	.142, .532
Middle	Cognitive Test	.711	.102	7.003	.000	.510, .912
	Reading	.493	.096	5.132	.000	.303, .683
High	Cognitive Test	.867	.103	8.397	.000	.663, 1.072
	Reading	.650	.128	5.057	.000	.396, .904

Note. CE = conditional effect; *SE* = standard error; CI = 95% confidence interval with the percentile method.

Figure 1

A Conceptual Additive-Multiple-Moderation Model. (For clarity, covariates are not included in the conceptual model.)

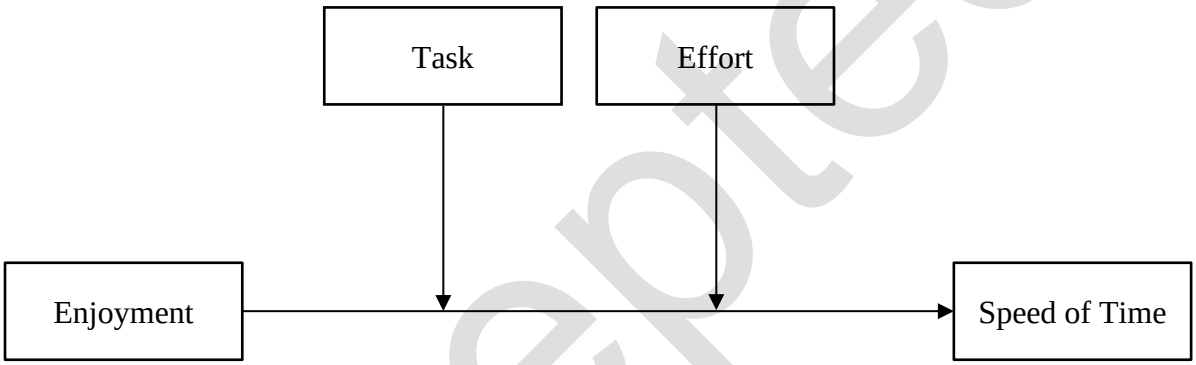


Figure 2

Simple Slopes Analysis for Each Task at Different Effort Levels in the Additive-Multiple-Moderator Model (Experiment 1).

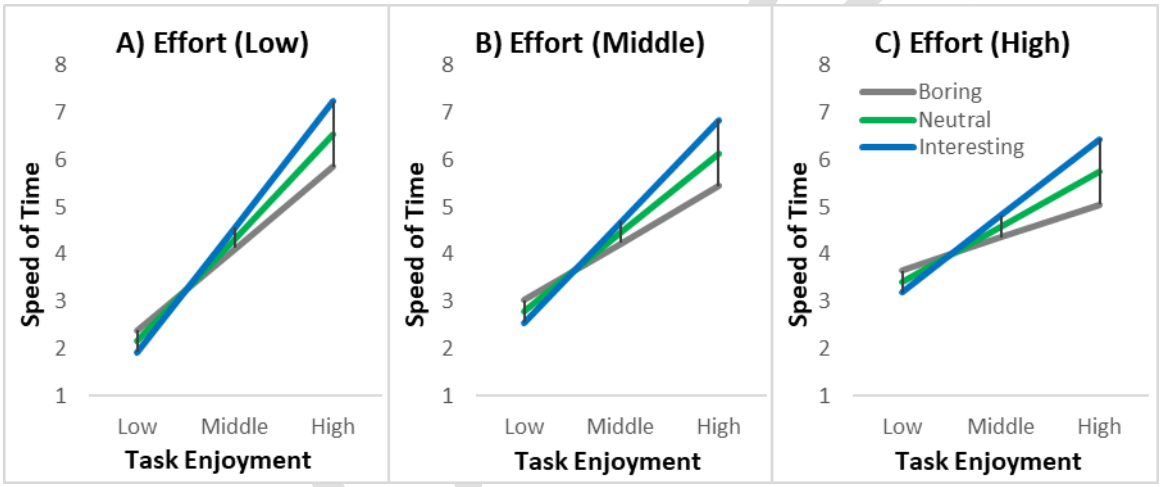
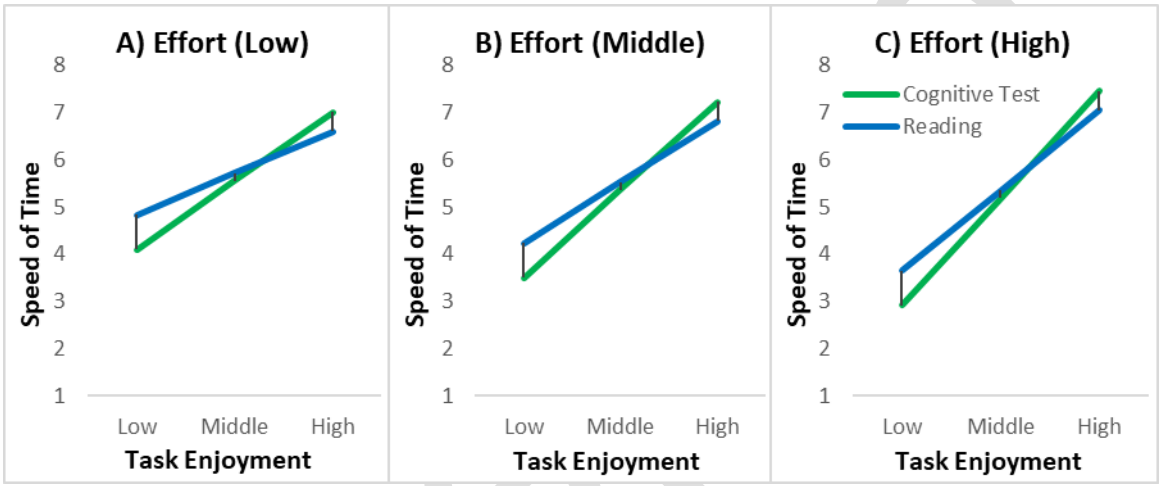


Figure 3

Simple Slopes Analysis for Each Task at Different Effort Levels in the Additive-Multiple-Moderator Model (Experiment 2).



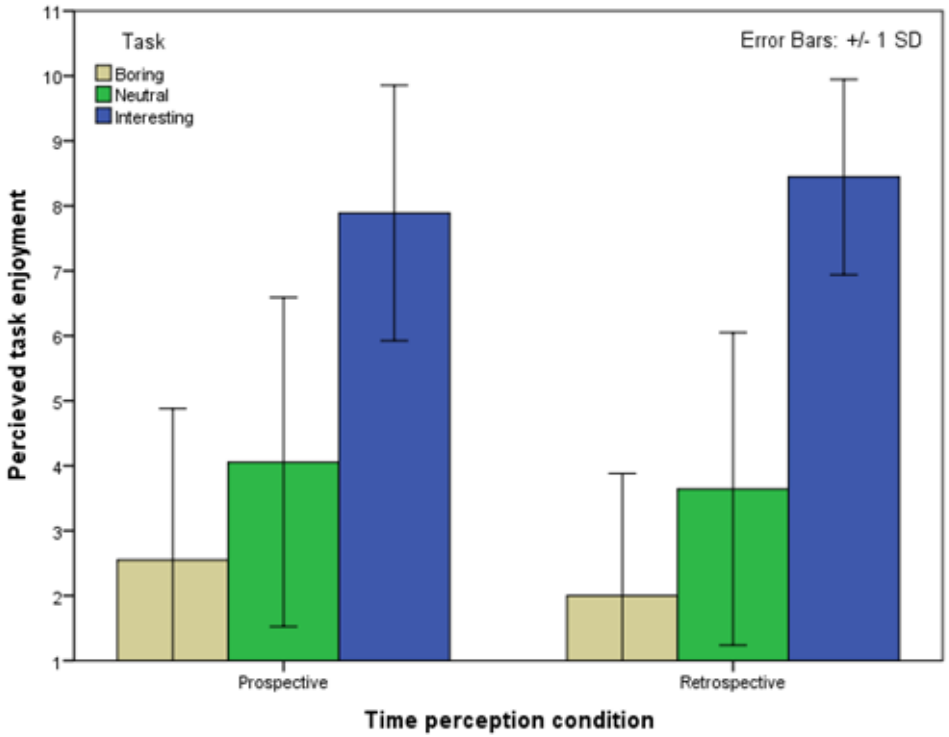
Online Resource

Online Resource 1. Descriptive statistics of perceived task enjoyment for each task and for each time estimation paradigm.

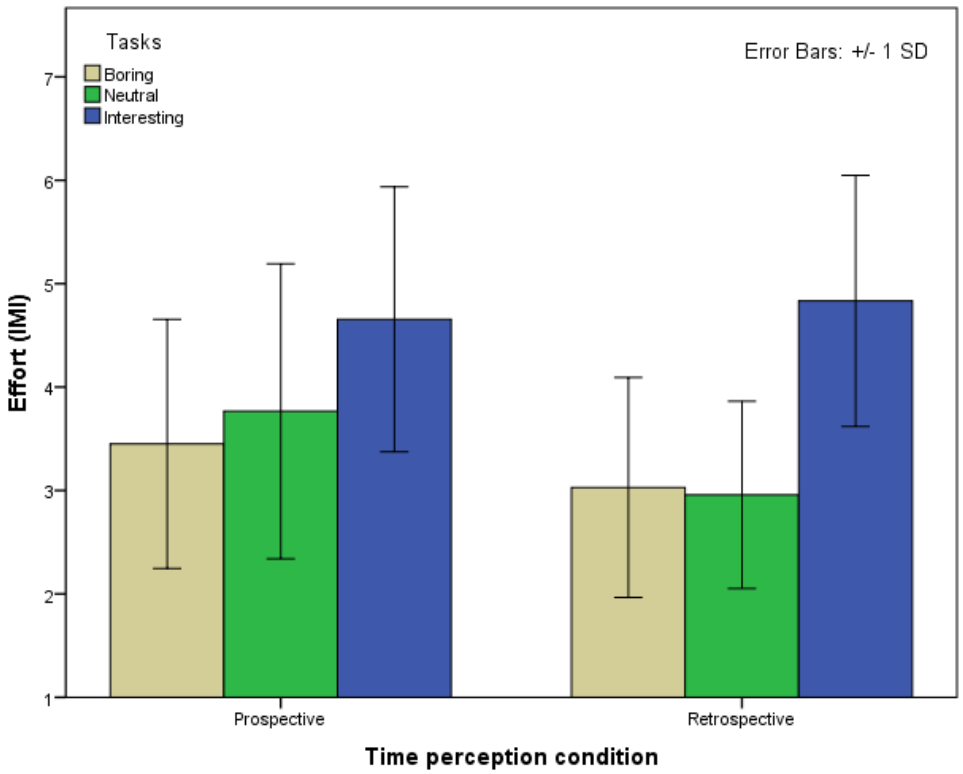
Online Resource 2. Descriptive statistics of perceived effort for each task and for each time estimation paradigm (Experiment 1).

Online Resource 3. Descriptive statistics of the perceived speed of time for each task and for each time estimation paradigm (Experiment 1).

Online Resource 1.



Online Resource 2.



Online Resource 3.