Do We Have Fun When Time Flies?

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ABSTRACT. The purpose of the present study was to assess the effects of distortions in time perception and the complexity of a task on mood and enjoyment of the task. Further, researchers sought to study factors that may affect time perception (e.g., immersion, task complexity, objective task duration). Seventy-seven undergraduate students participated in 1 of 6 conditions within a 2 (complexity) x 3 (duration) design. Although the experimental manipulations did not create the anticipated effects, subsequent analyses supported the hypotheses that, when time was perceived as passing quickly, participants experienced more positive mood change, $t(75) = 3.92$, $p < .001$, $\eta^2 = .17$. Further, immersion was positively correlated with distortions in time perception, $r(75) = .40$, $p < .001$, $r^2 = .16$, and mood change, $r(75) = .23$, $p = .02$, $r^2 = .05$. Regression analysis revealed that distortions in time perception mediated the relationship between immersion and mood change. Theoretical implications for self-perception theory and the concept of flow are discussed.

Time is a basic feature of human experience. Across societies, people have internalized different models of time through which they connect events, organize their lives, and attempt to come to terms with fundamental questions about life, death, and existence (Levine, 1997). As a species, people have many models of time that they use in everyday life. These models may vary according to the direction in which the *arrow of time* points (Núñez & Sweetser, 2006) or even whether time is seen as flowing in a linear way at all (Lee, 1950; Whorf, 1956).

Objective and Subjective Time

Despite this variety across societies, individuals' social and economic lives are structured in very real ways by both their efforts to standardize time (Levine, 1997; Sorokin, 1943) and their expectation that others structure time similarly. For example, when a friend promises to meet in an hour, it is not expected to have to wonder if this will be a fast hour or a slow hour. However, when someone arrives, one might (if the situation calls for it) judge the friend to be early, on time, or late based upon this objective standard of time passing. This is also true for shipments, transportation schedules, media events, communication over large distances, and the many varieties of coordination that allow the modern world to function. During interactions with other people, the expectation is that individuals will operate according to standardized objective time, in which the duration of every second is the same.

However, such standards and expectations may not apply in an individual's own psychological sphere. In a person's everyday experience, moments stretch or shrink, and may not be amenable to division into elementary units such as minutes or seconds. When people reflect on their experiences and try to estimate how much time has passed, it is easy to see the potential mismatch between their subjective experience of time and the standardized version. For example, someone immersed in a good

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conversation might think that only half an hour has passed when, in reality, a full hour has passed. In a situation like this (i.e., when a person's subjective temporal experience is surprisingly slower than the objective rate), an individual may be left with the feeling that time has flown. The opposite (i.e., the sensation of time dragging) is equally familiar. Much research has been devoted to understanding the causes of these changes in time perception.

Time Flies When We Are Having Fun

Everyday discourse frequently reflects commonsense beliefs. Everyone seems to know that "time flies when you are having fun." Recent research has demonstrated that this is more than just a saying. For a variety of reasons, enjoyable experiences are felt to pass more quickly than unpleasant (or less pleasant) ones (Droit-Volet & Meck, 2007; Gable & Poole, 2012; Iwamoto & Hoshiyama, 2011). For example, Iwamoto and Hoshiyama (2011) found that participants who reported more interest in completing a 24-piece jigsaw puzzle also felt the puzzle-solving task to pass more quickly than did participants who reported little interest in the task. Similarly, Gable and Poole (2012) found that time seemed to pass more quickly for participants who were pursuing intrinsically rewarding activities (e.g., family time, exercise, or eating a favorite food).

Likewise, other research has demonstrated that time seems to drag when individuals are not enjoying themselves (Danckert & Allman, 2005; O'Brien, Anastasio, & Bushman, 2011; Ratcliffe, 2012). Danckert and Allman (2005) found that participants who were bored experienced time as passing more slowly than those who were not bored. Similarly, O'Brien et al. (2011) found that participants who ascribed greater value to their personal time overestimated the length of a dull task, reported less interest in it, and walked away from the laboratory more quickly once the dull task was completed. In instances of depression, time is often described as slowing down or stopping (Ratcliffe, 2012).

We Also Have Fun When Time Flies

Emotions, enjoyment, and distortions in time perception all seem to be related. Sackett, Meyvis, Nelson, Converse, & Sackett (2010) demonstrated that participants who were made to feel time passing more quickly than normal reported enjoying a task more than participants who experienced time passing normally or more slowly than normal (Sackett et al., 2010). That is, not only does time seem to fly when one is having fun, but research has suggested that people also have fun when time flies. Sackett et al. (2010) proposed that time perception is used as a metacognitive cue where subjective temporal experience is referenced to establish hedonic evaluations of experiences. In other words, a person's awareness of time having passed either more quickly or more slowly than usual is a factor that is taken into account in the process of formulating judgments regarding how much or little they enjoyed an experience.

This finding was in line with both the James-Lange theory of emotions (James, 1884) and self-perception theory (SPT; Bem, 1972), which states that people may come to know their own emotional states by inferring them from observation of their own behavior. Over the course of decades, James Laird (Duclos & Laird, 2001; Laird, 1974; Laird & Bresler, 1992; Schnall, Abrahamson, & Laird, 2002) has repeatedly demonstrated that emotional experiences are contingent upon a subconscious awareness of expressive behaviors. For example, smiling or furrowing the brow seems to influence the degree to which an individual feels happy. Instead of the commonsense belief that people are smiling because they are happy, SPT suggests that the inference is more along the lines of "I am smiling, so I must be experiencing happiness" (Laird, 1974). Sackett et al. (2010) demonstrated that a subconscious awareness of distortions in time perception serves a similar purpose in the construction of emotional experiences. That is, "Time flew, so I must have been enjoying myself."

The Importance of the Task

Researchers seeking to understand the fluidity of time perception have focused on cognitive factors that are often linked to the nature of the activities that occupy people's time (e.g., task complexity and other demands on cognitive resources; Iwamoto & Hoshiyama, 2011; Ornstein, 1969; Pariyadath & Eagleman, 2007). This body of research has indicated that time tends to drag as cognitive demands increase. This idea has been summarized by Ornstein's (1969) storage-size metaphor, which claims that subjective duration is represented through metaphorical space that information takes up when encoded, with more complex information requiring more metaphorical space. Ornstein conducted five experiments that supported his theory that cognitive demands are linked to temporal perception and that subjective time seems to slow down as cognitive demands increase.

In an applied setting, Stetson, Fiesta, and Eagleman (2007) demonstrated that people in a life-threatening situation remember the event taking longer than it really did. The authors suggested that this dilation of subjective duration is due to increased encoding of information during the event. Along similar lines, Vohs and Schmeichel (2003) demonstrated that demands for self-regulation increase the perceived duration of events. These researchers asked some of their participants to suppress their reactions during exposure to emotional stimuli. Other participants were not asked to self-regulate. In their study, self-regulators estimated that the task took significantly longer than nonregulators. Finally, Iwamoto and Hoshiyama (2011) demonstrated that task complexity is an important factor in time perception. All other things being equal, more complex tasks are experienced as taking longer than less complex tasks. These findings all converged on the notion that perception of time fluctuates with the level of cognitive demand.

Getting "Into It": Immersion, Flow, and the Passage of Time

Other research has suggested that objective characteristics of the task are not sufficient to explain distortions in time perception. This work focuses on the interaction between the person and the task at hand. Task immersion is one factor that is strongly associated with distortions in time perception. Immersion is a feeling of full concentration including effortless attention and focus on the task at hand, emotional involvement, and blocking out of external distracters.

Nakamora and Csikszentmihalyi (2001) suggested that task immersion is most likely to happen when there is a good balance between the difficulty of the task and the skill level of the individual performing the task. In this situation (entailing demand-skill correspondence and task immersion), the experience of *flow*, an intrinsically rewarding state of intense concentration on the present task, is likely to occur (Csikszentmihalyi, 1975). Flow is an outcome from the act of being immersed into a task where one receives an intrinsic reward from the experience. Flow experiences include immersion, but not every experience of immersion is a flow experience. One especially relevant characteristic of flow experience is the tendency for time to pass more quickly than normal. That is, time often seems to fly when a person is immersed in a task that optimally matches their skill level.

The Present Study

The current study tested several hypotheses, which replicated and synthesized previous research. First, we hypothesized that participants who experienced an increase in the perceived speed of time (i.e., time flying) while performing a reading task would demonstrate an increase in positive subjective experience (i.e., mood and task enjoyment). We suggested that this would be because of the dynamics of self-perception. The feeling that time has passed more quickly (or more slowly) than usual would be used as a metacognitive cue within the process of formulating an experience as suggested by the James-Lange theory of emotion and Self-Percetion Theory and demonstrated by Sackett et al. (2010). Next, we hypothesized that participants who performed a more complex task would experience significantly less positive mood and less enjoyment than participants performing a less complex task. We suggested that this would be because participants would find it more difficult to become immersed in more complex tasks. Also, as Iwamoto and Hoshiyama (2011) demonstrated, increased complexity tends to make time drag, and lower complexity makes time pass quickly. Finally, we hypothesized an interaction between changes in time perception and task complexity. We suggested that this interaction would exist because, consistent with Csikszentmihalyi's work on flow, the lack of immersion in a more complex task would create a dilation of subjective time (i.e., the feeling that time has dragged) that would counteract our attempt to induce the feeling that time has flown. On the other hand, greater immersion in a less complex task was expected to enhance the effect of the feeling that time has flown, producing an even stronger increase in positive subjective experience.

Method

Participants

Seventy-seven undergraduate students from an eastern university were recruited through the online sign-up SONA software system (55 women, 22 men; M_{age} = 20.60, *SD* = 6.84). Most of our participants (63 of 77) self-identified as European American. Only five participants self-identified as either American/Alaskan Native, Asian, or African American. The remaining nine participants self-identified as other. Participants were compensated with credit toward fulfillment of the research requirement for their general psychology course (if applicable) or extra credit in another class (if offered).

Research Design

The present research used a 2 x 3 between-subjects design in which all participants agreed to complete a 10-min reading task. The independent variables were task complexity (low, high) and distortions in time perception (flying, normal, dragging). We manipulated the complexity of the reading task by asking participants in the low complexity condition to read a passage normally. Participants in the high complexity condition read the same passage with the text presented in mirror image. We also sought to manipulate our participants' experience of time. We operationalized this in terms of task duration. Although all participants believed that the reading task would last 10 min, we manipulated the actual duration of the task (5, 10, or 15 min) to create the feeling that time had flown in the 5-min condition or dragged in the 15-min condition. A similar procedure successfully produced distortions in time perception previously (cf. Sackett et al., 2010).

Task enjoyment and mood were the dependent variables of interest. To check whether we had successfully manipulated participants' time perception and help support our theoretical explanation for the hypothesized effects of the independent variables, we assessed participants' immersion in the experimental task and the degree to which participants felt time either flying or dragging.

Materials

Brief Mood Introspection Scale. (BMIS; Mayer & Gaschke, 1988) A 10-item, 7-point Likert-type scale was used to assess mood before and after the reading passage. Scores range from 10 to 70, with higher scores representing more positive mood. The BMIS has a Cronbach's alpha of .80. For the current sample, Cronbach's alpha was .80 on the pretest and .85 on the posttest.

Reading passage. The reading passage included Chapters 5 and 6 from Todd Strasser's (1981)novel *The Wave*. It was printed in both normal (low complexity) and mirror image (high complexity) format. We chose to use a reading task for two reasons. First, we chose an excerpt from a novel in the hope that this would facilitate task immersion. Our second reason for choosing a reading task was that it lent itself to manipulations of complexity, through necessary mental flipping to understand the words, similar to that used in other current research in cognitive psychology (Koriat, Norman, & Kimchi, 1991; Zhang, Qui, Huang, Zhang, & Bao, 2009). Presenting the text in mirror image is a straightforward way of making the reading task more complex and one that we thought would highlight the presumed connection between task complexity and immersion.

Overall Task Enjoyment Scale (OTES). A study-specific scale was created to measure enjoyment of the task and distortions of time perception. The first item measured enjoyment over a 9-point Likert-type scale, with higher scores indicating greater enjoyment. Distortions in time perception, the second item, were assessed over a 9-point Likert-type scale, with higher scores indicating time being perceived as going by more quickly than usual. After data collection was complete, scores on this scale were centered around 0 so that negative scores indicated time passing more slowly than usual and positive scores indicated time passing more quickly.

Task Immersion Scale (TIS). Immersion was measured using a modified version of the Immersive Tendency Questionnaire (ITQ), created by Witmer and Singer (1998). The original ITQ consisted of 19 items, each answered using a 5-point Likert-type scale, with a Cronbach's alpha of .78. Weibel, Wissmath, and Mast (2010) found the ITQ to include two factors: emotional involvement and absorption. The present study focused on absorption. Therefore we used a set of four items based on the absorption subscale proposed by Weibel et al. Items included "While performing the reading task, to what extent did you feel you lost track of things around you?" and "How effectively were you able to block out external factors while you were reading?" Each of the four items was answered using a 5-point Likert-type scale, with higher total scores representing greater task immersion. In the current sample, Cronbach's alpha was acceptable ($\alpha = .62$).

Procedure

After human subjects review board approval (#1213-17-01) was obtained, researchers constructed an environment where time manipulation would not be confounded by other variables (e.g., temperature, time awareness). To do so, a room was set up without clocks, and at a stable temperature. After providing informed consent, a group of participants was instructed to fill out a demographic scale and the BMIS to acquire a baseline mood score. The examiner then explained to the participants that they would be asked to read a passage to the best of their ability for 10 min. In reality, participants were assigned to reading the passage for either 5, 10, or 15 min. Following completion of the reading task, participants were instructed to complete a second BMIS, the OTES, and the TIS. Participants received a debriefing sheet to emphasize that their mood might have changed as a result of an experimenter-implemented time manipulation, but the normal rate of time had not changed.

Results

Was Time Perception Effectively Manipulated?

In the present study, the duration and complexity of the reading task were manipulated for the purpose of producing distortions in time perception. It was hypothesized that distortions in time perception would affect both participants' mood and their enjoyment of the reading task. Before examining the effects of the experimental manipulations on mood and enjoyment, it was important to assess the effectiveness of our experimental manipulations on time perception. To do this, we performed a factorial Analysis of Variance (ANOVA) using scores on the second item of the OTES. This item asked participants to reflect back on the 10 minutes they spent performing the reading task and indicate whether that time seemed to pass more slowly or quickly than normal. Significant main effects on time perception were observed for task duration, $F(2, 71) = 10.29$, $p < .001$, $\eta^2 = .19$, and task complexity, $F(1, 71) = 4.12$, $p = .05$, $\eta^2 = .04$. As expected, time appeared to pass the fastest for participants in the 5-min group (regardless of complexity) and slowest for those in the 15-min group. Similarly, time passed significantly more quickly for participants in the low complexity condition, regardless of task duration.

The analyses also revealed a significant interaction between task complexity and task duration on time perception, $F(2, 71) = 5.60$, $p = .002$, $\eta^2 = .10$. Although time moved faster than normal for participants in the 5-min condition (regardless of complexity) and slower than normal for participants in the 15-min condition (regardless of complexity), participants in the 10-min condition were split. Among this group, participants in the low complexity condition experienced time flying, while time dragged for participants in the high complexity group. Interestingly, time seemed to have passed most quickly for those in the 5-min high complexity condition, and second fastest for those in the 10-min low complexity condition (see Figures 1 and 2).

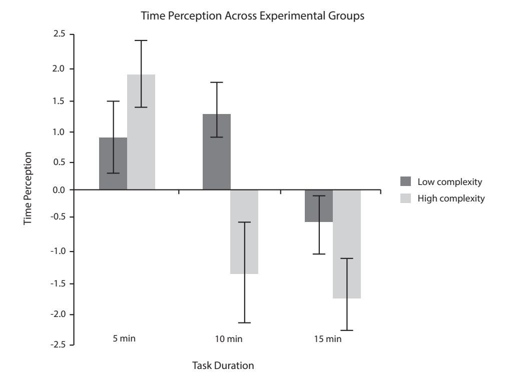
A Closer Look: What Happens When Time Flies?

Despite our apparent success at manipulating time perception by changing the duration of the task, we were puzzled by the lack of any consequent effect of duration on either mood, $F(2, 71) = 0.59$, $p = .56$, $\eta^2 = .01$, or enjoyment, $F(2, 71) = 1.51$, $p = .23$, $\eta^2 = .03$. This contradicted previous research (Sackett et al., 2010), which indicated the hedonic value of distortions in time perception.

A promising finding regarding the effect of

FIGURE 1

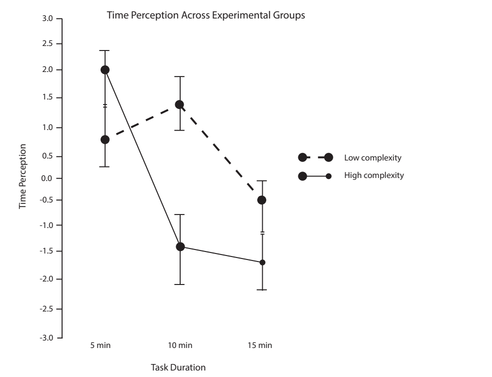
Mean Time Perception Scores Across Experimental Groups



Note. Positive scores represent the experience of time moving more quickly than normal. $N = 77$.

FIGURE 2

Distortions in Time Perception Scores Across Experimental Groups



Note. There was a significant interaction between task complexity and task duration on time perception, $F(2.71) = 5.60$, $p = .002$, $\eta^2 = .10$, as well as significant main effects for task duration, $F(2,71) = 10.29$, $p = .001$, $\eta^2 = .19$, and task complexity, $F(1,71) = 4.12$, $p = .046$, $\eta^2 = .04$. Positive scores represent time passing more quickly than normal. Time seemed to have passed most quickly for those in the 5-min high complexity condition, followed by those in the 10-min low complexity condition.

distortions in time perception on mood emerged when we divided our participants into two groups using OTES scores: those who experienced time passing more quickly than usual and those who did not, regardless of the duration and complexity of the task being performed. We categorized participants as having experienced time passing more quickly if they produced a positive score on the OTES (i.e., the fast group). Those who did not produce a positive score on the OTES were categorized as having experienced time passing more slowly than usual (i.e., the slow group). We ran an independent-samples *t* test to compare mood change scores from the fast group ($n = 33$, $M = 1.24$, $SD = 7.67$) and slow group ($n = 44$, $M = -5.45$, $SD = 7.24$). The results indicated that participants who experienced time flying had significantly more positive changes in mood scores than those who did not, $t(75) = 3.92$, $p < .001$, $\eta^2 = .17$, thus providing support for the hypothesized effect of distortions in time perception on mood. In addition, we observed the hypothesized main effect of task complexity on mood, $F(1,71) = 14.90$, $p < .001$, $\eta^2 = .16$). Participants in the high complexity group ($M = -5.69$, $SD = 8.18$) experienced significantly less positive mood change than participants in the low complexity group ($M = 0.61$, $SD = 6.73$).

We observed a similar pattern for enjoyment, with participants in the fast group ($M = 4.76$, $SD = 2.05$) showing slightly higher scores than participants in the slow group ($M = 4.14$, $SD = 2.54$). However, this difference was not statistically significant, $t(75) = 1.15$, $p = .13$, $\eta^2 = .02$. It seems that task complexity alone accounted for the degree to which participants enjoyed their assigned reading task, $F(2,71) = 20.73$, $p < .001$, $\eta^2 = .22$.

Although there was no significant main effect of task duration on mood change or a significant duration x complexity interaction, we were able to detect significant effects when we split our participants according to their experienced distortions in time perception. By approaching the data through this lens, we were able to detect a significant difference in mood change scores between participants who experienced time flying and those who did not. Specifically, participants who experienced time flying demonstrated more positive mood change than participants who did not. These results indicated that distortions in time perception seemed to be having their hypothesized effects on mood. However, that effect could not be traced back to our manipulation of task duration. This suggests that the duration manipulation might not have been as successful as our initial manipulation suggested. This led us to look even more closely at whether manipulating task duration was an effective way of inducing distortions in time perception.

Did Task Duration Reliably Affect Time Perception?

In our experimental design, we created three task duration conditions: 5, 10, and 15 min. The intention was that the 10-min condition would be a control condition and that participants in that group, on average, would report no distortions in time perception. A one-sample *t* test supported our assumption by demonstrating that posttest OTES scores for this group of participants ($M = -0.24$, $SD = 2.55$) were not significantly different from 0, $t(24) = -0.47$, $p = .64$, $d = -.09$. Another indication that this group worked well as a control group was the fact that 12 out of 25 participants (48%) produced positive OTES scores, and 13 out of 25 (52%) did not. A χ^2 goodness of fit test showed that this distribution was not significantly different than what was expected by chance, $\chi^2(1, N = 25) = .04$, $p = .84$. This even split indicated that participants in this condition did not reliably experience any specific kind of distortion in their perception of time. The split also closely mirrored the number of participants in the 10-min, low complexity group (11) and 10-min, high complexity group (14), indicating that the 10-min condition was a 'clean slate' upon which the effects of task complexity could come through most clearly.

Participants in the 15-min condition behaved very differently. By extending the duration of the reading task beyond the expected 10 min, we hoped to induce the feeling that time had passed more slowly than usual. This would manifest itself as negative OTES scores. A one-sample *t* test supported this expectation by demonstrating that OTES scores for this group ($M = -1.13$, $SD = 1.87$) were significantly below 0, $t(23) = -2.94$, $p < .001$, $d = -.60$. Only 3 out of 24 (13%) participants in this group produced positive OTES scores, with another four participants reporting that time passed normally. Seventeen out of 24 participants in this group (70.83%) produced negative OTES scores. This split was consistent across complexity levels. Nine out of 13 participants in the low complexity condition and 8 out of 11 in the high complexity condition produced negative OTES scores. A χ^2 goodness of fit test showed that this distribution was significantly different than what would be expected by chance, $\chi^2(1, N = 24) = 4.17$, $p = .04$.

These findings suggested that participants in this condition reliably experienced time passing more slowly than normal, regardless of task complexity.

However, participants in the 5-min condition did not follow our expectations as clearly. We expected these participants to experience time passing more quickly than normal, as shown by positive OTES scores. A one-sample t test supported this expectation. Scores for this group (M = 1.36, SD = 2.02) were significantly above 0, $t(27) = 3.55$, $p < .001$, $d = .67$. This suggested that participants in this condition not only experienced the kind of distortions in time perception that we expected, but that the effect was even stronger than in the 15-min condition. Looking more closely at the data, however, only 18 out of 28 (64%) of participants in the 5-min group produced positive OTES scores. More than one third of participants in this group did not produce positive OTES scores. This split was consistent across complexity conditions, with 9 out of 14 participants in each complexity condition producing positive OTES scores. A χ^2 goodness of fit showed that this distribution was not significantly different than what would be expected by chance, $\chi^2(1, N = 28) = 2.29$, $p = .13$. This suggested that, regardless of task complexity, participants in this condition did not reliably experience the expected distortions (i.e., shortening) of time perception.

Based on this participant-level manipulation check, we believe that we did not successfully induce distortions in time perception by manipulating task duration. Specifically, participants in the 5-min condition did not experience time flying at a rate that was significantly greater than chance. This accounts for why we did not see a significant main effect for task duration on mood and why we did observe the hypothesized significant difference in mood change when participants were grouped based on their OTES scores. This, together with fact that there were no significant effects of either duration, $F(2, 71) = 0.63$, $p = .53$, $\eta^2 = .02$, or complexity, $F(1, 71) = .25$, $p = .62$, $\eta^2 < .01$, on immersion scores, and no significant interaction, $F(2, 71) = .38$, $p = .68$, $\eta^2 = .01$ (see Figure 3), led us to set our experimental manipulations aside and analyze the functional relationships between time perception, immersion, and mood change more directly.

Building a Functional Model

Although it was difficult to see how distortions in time perception, immersion, and mood change fit together when looking through the lens of our manipulations of task duration and complexity, a clearer picture emerged when we analyzed the direct measures of those variables. Increasing task immersion, as reflected in TIS scores, was associated with the feeling of time passing more quickly, $r(75) = .40$, $p < .001$, $r^2 = .16$, and increasing positive changes in mood, $r(75) = .23$, $p = .02$, $r^2 = .05$. Following up on these preliminary findings, we performed regression analyses to determine whether distortions in time perception and task immersion were significant predictors of mood change.

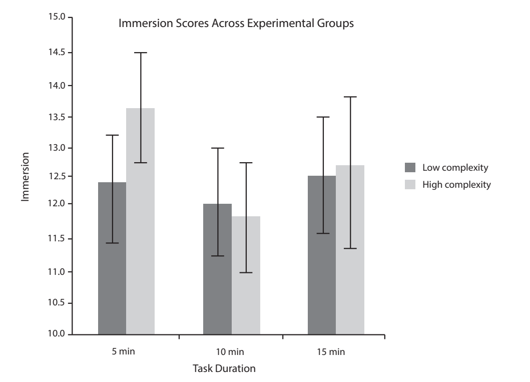
Using stepwise regression analyses, we determined that immersion was a significant predictor of mood change, $\beta = .23$, $t(76) = 2.05$, $p = .04$. Greater task immersion predicted positive changes in mood. The power of task immersion to predict mood change was weakened considerably when distortions in time perception were included in the model, $\beta = .06$, $t(76) = .51$, $p = .61$. In this context, immersion alone was no longer a significant predictor of mood change. Subsequent mediation analysis performed using Baron and Kenny's (1986) four-step technique revealed that distortions in time perception mediated the relationship between immersion and mood change (see Figure 3 and Table 1). That is, immersion positively predicted distortions in time perception, $\beta = .40$, $t(76) = 3.79$, $p < .001$, and distortions in time perception predicted mood change, while controlling for the effect of immersion, $\beta = .43$, $t(76) = 3.80$, $p < .001$. See Figure 4 for an illustration of these functional relationships.

Discussion

Previous research has established that manipulations in task complexity distort time perception

FIGURE 3

Mean Immersion Scores Across Experimental Groups



Note. Higher scores represent greater immersion in the reading task. $N = 77$.

(Iwamoto & Hoshiyama, 2011; Ornstein, 1969; Pariyadath & Eagleman, 2007; Stetson et al., 2007; Vohs & Schmeichel, 2003). In addition, manipulating task duration has been demonstrated to produce distortions in time perception, which can affect participants' enjoyment of the experimental task (Sackett et al., 2010). The present study synthesized these works by examining the effects of both task duration and task complexity on task enjoyment and mood. It was hypothesized that duration and complexity would affect mood and enjoyment by producing distortions in time perception. Following self-perception theory (Bem, 1972; Laird, 1974), we expected participants to perceive and interpret distortions in time perceptions as signs of their own emotional state and task enjoyment.

Initial findings indicated that task complexity affected time perception, task enjoyment, and participants' mood in the expected directions. In the mirror-image condition, participants experienced time as passing more slowly, reported enjoying the task significantly less (see Figure 5), and experienced significantly less positive mood change (see Figure 6) than participants in the low complexity condition. These findings directly supported our hypotheses and corresponded with previous research findings.

Initial findings regarding task duration were not as clear-cut. As expected, the duration of the reading task affected participants' perception of time but did not affect either their mood or enjoyment of the reading task. This mixed set of findings prompted us to perform a series of manipulation checks, which led us to abandon the factorial structure of the original experiment and analyze direct measures of the relevant variables (i.e., distortions in time perception, immersion, mood change, and task enjoyment).

Subsequent analyses demonstrated that people do, in fact, have fun when time flies. The experience of time flying was found to predict positive changes in mood. Further, the present study has also demonstrated that distortions in time perception are predicted by task immersion. When a person becomes immersed in a task, they are likely to experience time as passing more quickly than usual, which can produce positive mood changes. In other words, becoming immersed in a task sets the stage for improved mood, but the experience of time passing quickly is a necessary ingredient. Without distortions in time perception, simply becoming immersed in a task is not sufficient to produce better mood. In this sense, our data suggested that people do tend to enjoy themselves more when time seems to fly. This directly supported our primary hypothesis.

The important role of distortions in time perception is consistent with the theoretical basis of the present study, the James-Lange theory of emotion (James, 1884) and self-perception theory (SPT; Bem, 1972; Laird, 1974). According to this approach, the awareness of time having passed more quickly than usual is taken as part of the experience of improved mood. Just as Laird (1974) suggested that a person may infer their own happiness from an awareness that they are smiling, our participants seemed to experience enhanced mood because of their awareness that they felt time flying. This corroborates the empirical support for SPT supplied by Laird and his colleagues (Duclos & Laird, 2001; Laird & Bresler, 1992; Schnall et al., 2002) as well as by Sackett et al., 2010, and

TABLE 1

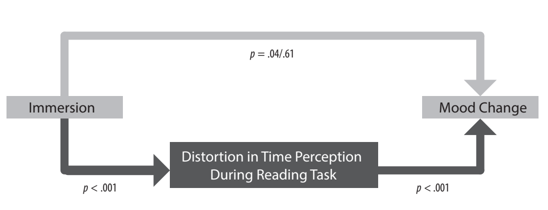
Stepwise Regression With Immersion and Distortions in Time Perceptions as Predictors of Mood Change (*N* = 77)

Predictors	B	95% CI	*M*	*SD*
Step 1				
Immersion	.23*	[0.02, 1.15]	12.53	3.20
Step 2				
Immersion	.06	[0.42, -0.72]		
Distortions in time perception	.43***	[0.07, 2.22]	0.65	2.38
Outcome–Mood Change			**-2.58**	**8.10**

Note. R^2 = Proportion of outcome variable variance explained by predictors.
$^*p < .05$, $^{***}p < .001$, Cohen's f^2 = effect size.
Step 1 $R^2 = .05$, $F(1, 75) = 4.18$, $p = .04$; Cohen's $f^2 = .06$.
Step 1 to Step 2 $\Delta R^2 = .16$, $\Delta F(1, 74) = 14.45$; Cohen's $f^2 = .18$.
Step 2 $R^2 = .21$, $F(2,74) = 9.69$, $p < .001$; Cohen's $f^2 = .27$.

FIGURE 4

Functional Relationships Between Immersion, Distortions in Time Perception, and Mood Change



Note. Distortions in time perception during the reading task mediated the relationship between immersion and mood change. On its own, immersion (positively) predicted mood change ($p = .04$). When distortion in time perception was added to the model, this relationship disappeared ($p = .61$). The significant predictive relationships between immersion and distortion in time perception ($p < .001$), as well as between distortion in time perception and mood change ($p < .001$), demonstrated the mediational role of distortion in time perception. Positive scores represent positive change in mood. $N = 77$.

suggests that time perception may be an integral but relatively unexplored precursor of positive mood change.

Although we were able to build a functional model of mood change that supported our hypotheses and corroborated SPT, the findings regarding task enjoyment did not support our hypotheses. Enjoyment was not affected by task duration and was not predicted by distortions in time perception. We were unable to integrate enjoyment into our functional model. Task complexity was the only factor that influenced how much participants enjoyed the reading task. Both task enjoyment and mood were uniformly low for the high complexity group, regardless of duration. There are several potential methodological explanations for this finding. Our complexity manipulation (i.e., presenting the stimulus reading in mirror-image) might have been too demanding, given the participants' level of investment. The novelty of the task (both compared to what participants do in their everyday lives and as participants in other studies) might also have led the participants to simply react to the task, rather than engage with it. A more subtle manipulation (i.e., a task that does not differ from the low complexity version or from everyday activities in such an obvious way) might be more suitable for future research. Finally, another reason for this negative result might be a lack of power in the experiment. Practical constraints (including the looming graduation of the first author and a lack of research assistants to help administer the study) limited the sample size and, consequently, the power of the analyses.

From Mood to Flow

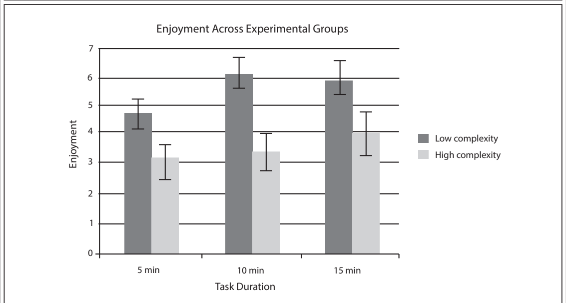
Although the potential mismatch between the demands of our experimental task and the interests and motivations of our participants might have undermined some of our initial hypotheses regarding the effect of task complexity, this also highlighted the potential relevance of the concept of flow (Csikszentmihalyi, 1975). Flow involves full engagement in a task and is characterized by both positive affect and a feeling that time has passed quickly. Our results suggested a central role of time perception in the experience of flow and the intrinsic emotional rewards that are characteristic of such experiences. Specifically, the positive subjective experience associated with flow seems to depend upon the distortion of time perception. In both Cszikszentmihalyi's theoretical elaboration of flow and in our findings, positive changes in mood are predicted by task immersion. The present study contributed to the understanding of the process by which flow experiences emerge by demonstrating that distortions in time perception mediate the predictive relationship between task immersion and positive mood change. In this way, the same process of registering changes in a person's own subjective flow of time that may lie at the center of mood change may also be integral to the emergence of flow experiences.

The concept of flow may also facilitate understanding why our task complexity manipulation did not produce its anticipated effects. In the present study, we manipulated task complexity with the intention of determining whether the effects of distortions in time perception (on mood and task enjoyment) would vary along with the complexity of the task being performed. This hypothesis was not supported. Mood and enjoyment were uniformly lower for participants in the high complexity task, regardless of the objective duration of the reading task. The same pattern held when participants were grouped according to whether they experienced time flying (although only very few participants in this group experienced time flying). The more complex task seemed to frustrate most participants.

Csikszentmihalyi has suggested that an optimal match between one's skill level and the complexity of a task helps set the stage for flow experiences. The present study did not include any measure of participants' pre-existing level of mirror-image reading skill level, so it is impossible to know if there was any mismatch between the task and participants' skills. However, it is not unreasonable to speculate that participants might have been unwilling to deploy existing skills and might have objected to the difficulty of this experiment compared to others used to gain course credit. Given

FIGURE 5

Mean Enjoyment Scores Across Experimental Groups



Note. Higher scores represent greater enjoyment of the reading task. $N = 77$.

this potential lack of motivation, it is not surprising that enjoyment scores were uniformly low in the high complexity group and that positive mood change did not emerge. This was even true in the 5-min condition, where the reading task was (objectively) much shorter than expected and most participants (9 out of 14) experienced time moving more quickly than usual. Although the small sample size was clearly an issue, providing participants with alternative forms of motivation (e.g., stimulating a testing situation with the promise of interesting information about oneself) might have lead them to engage with the reading task differently. In the end, however, the major reason for the lack of the hypothesized interaction was most likely the ineffectiveness of the task manipulation and a lack of power caused by our small sample size.

Future Directions: Exploring the Dynamics of Flow

Future research can shed further light on the importance of time perception as the linchpin in and clearest indication of flow. Are our time perception mechanisms integral for achieving the flow state? Is such a state possible in the presence of lesions to the brain areas responsible for the perception of time on the scale of minutes to hours? Can distortions in time perception indicate if someone is in a state of flow, or even in a state of boredom, or anxiety? This type of research may shed light on the ways in which time perception is fundamental not only the phenomenon of flow, but for intrinsic reward mechanisms more generally.

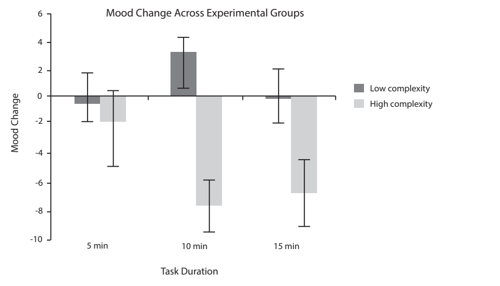
Our findings also suggested that time perception mechanisms may be involved in a wider system of processes that work together systemically to give shape to our stream of consciousness. Specifically there may be moment-to-moment fluctuations in immersion, time perception, enjoyment, and mood that were not captured by our study. In the present study, these factors were only measured at the end of the reading task. A design that incorporates constant monitoring of attention/distraction (e.g., following shifts in eye gaze) may help to reveal more nuanced information about differences in how one commits cognitive resources toward an attention-demanding task across different levels of complexity. Such an approach may also help to distinguish between two separate (but related) effects on time perception: (a) the effect of initial interest in a task on time perception early in a task, and (b) the effect of immersion and sustained focus on time perception as the task continues (and whether interest is required for the development of full-blown immersion).

This type of research would be especially interesting in light of how time perception changes along with task duration and complexity (see Figure 1). Participants in the 5-min high complexity condition experienced time passing fastest, with a significant slowing of time for their 10-min counterparts. Participants in this group also produced high immersion scores. This pattern (high immersion together with a speeding up of time) was unique to the high complexity group and is suggestive of a flow-like experience, which then dissipated under longer exposure to the high complexity task. This was accompanied by a number of trends that are theoretically suggestive. For example, for participants in the high complexity condition, distortions in time perception varied along with immersion. The same pattern did not hold for the low complexity group, where there were no differences in immersion across the task duration groups. The differences in these patterns suggested that task complexity may play an important role in the relationship between immersion and distortions in time perception, which we have demonstrated is predictive of positive changes in mood. Future research can address both the role of task complexity in the emergence of flow states and whether task complexity might influence the speed at which flow states emerge and dissipate.

In applied settings, it would be important to further understand how cognitive factors (e.g., task complexity, immersion, processing capability, attention) affect time perception. Slight manipulations in these cognitive factors may help to influence mood and performance in work and school contexts. In these contexts, task complexity would be an especially relevant variable that could be easily manipulated in an effort to tailor

FIGURE 6

Mood Change Across Experimental Groups



Note. Positive scores represent positive change in mood. $N = 77$.

our experiences and the experiences of those with whom we collaborate.

If, as Sackett and colleagues (2010) have suggested, individuals use perceptions of the flow of time as a metacognitive cue used in framing an event, it may be possible to look forward to a day when we can reshape our everyday experiences by manipulating the subjective flow of time. The present study advanced the overall understanding of time perception and its connection with subjective experience of an event. It seems that, when time passes quickly, people have a more positive experience. Further, we replicated work on how time perception is constructed. We also furthered the understanding of the role that time perception plays in a flow experience and that immersion into a task significantly contributes toward a positive experience only if time perception has been altered accordingly. Understanding how to manipulate time perception to a desirable rate may be an important step in improving everyday life. Our work may suggest that time perception is a malleable intrinsic motivator, which people continuously seek to shape in a satisfying manner. Although people are not always conscious of their perception of time, time perception does affect the way that people feel about their experiences.

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