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The Effects of Social Task Setting on Time Perception

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Abstract

This study investigates the effects of the social setting on prospective time estimation, how time is perceived when a task is performed (i) alone, (ii) with a collaborative, or (iii) with a competitive partner. *N*=90 participants were tested (30 in each condition). Participants performed a concurrent Simon task for three different durations (15, 30 and 45 seconds) which was followed by a time reproduction phase. Results revealed a main effect of social condition. Reproduction ratios in dual conditions were smaller than in the single condition and also smaller in the competitive condition compared to the cooperative condition. The results provide first evidence that social condition affects time estimation: time "flies" when we work together, in particular when we compete with a partner, showing that cognitive and social processes are heavily intertwined.

Keywords: time cognition; time perception; joint task; joint action; social Simon effect; social cognition; prospective time estimation

Introduction

The passage of time has always captured the curiosity of humans. As archaeological studies revealed sundials were in use some 3500 years ago (Vodolazshkaya, 2014). However, measuring the passage of time with clocks is not the same as the "feeling" of how much time has passed. Therefore, it has been suggested that humans have internal and possibly innate mechanisms for keeping track of time and these mechanisms have been studied and explained with internal clock models which facilitate the understanding of how cognitive factors can affect time estimation (Droit-Volet, 2013).

This study brings together two lines of study in cognitive science: time perception and joint action. Time perception is a basic cognitive ability implied in a wide variety of experimental tasks and daily activities (Grondin, 2010). Forming joint attention and performing joint action is another cognitive ability which has recently been the focus of several studies showing that people's performance in any task is heavily affected by joint attention and joint action (Sebanz, Bekkering, & Knoblich, 2006; Sebanz, Knoblich, & Prinz, 2003; Vesper et al., 2011). Also, studies in the literature suggest that time perception might be under the influence of a person's mood at that time (Droit-Volet & Meck, 2007).

The purpose of this study is to provide an experimental research paradigm linking the social aspect of the task setting to participants' prospective time estimation during that task, in order to investigate the effects of the social setting of the task on time perception.

Time Perception

There are dedicated and intrinsic models for time processing (Ivry & Schlerf, 2008). The dedicated models are modular, such as the Attentional Gate Model (Block & Zakay, 2006) or the cerebellar timing hypothesis (Ivry et al., 2002). On the other hand, intrinsic models suggest that time perception is distributed in various neural networks instead of a certain part of the brain (Reutimann et al., 2004).

The Attentional Gate Model contains a pacemaker which emits pulses continuously on a certain rate, and it can only be affected by arousal on a small scale. These pulses flow through an attentional gate, which is regulated by an executive function that determines whether attentional resources should be directed to the task at hand or to the keeping of time, which might be affected by diverting attentional resources to another task. A switch between the attentional gate and the counter starts or stops the connection, and the counter system keeps track of how many pulses have passed since the beginning of the event and stores that information in memory. Later, the number of pulses are retrieved from memory to represent how much time has passed during the given event. Then the decision on the amount of time that has passed is based on the latest information from the counter and the beginning of the counting of the pulses. The additional attentional mechanism for the explanation of mistakes in time estimation seen in humans, especially when there are other attention-demanding tasks in parallel with time estimation (Block & Zakay, 2006).

The temporal paradigm used in this study is prospective duration judgment, also called "experienced duration" (Block, 2014). In this paradigm, participants are aware that they will perform a time reproduction after some experienced duration (Zakay & Block, 2004). Participants use their attentional resources to keep track of time while they are performing a secondary task during that interval.

In accordance with the Attentional Gate Model (Block & Zakay, 2006), the amount of attention devoted to keeping track of time decreases in more demanding secondary tasks, e.g., executive tasks, compared to easier tasks, which results in an underestimation of the actual duration of the interval (Duzcu & Hohenberger, 2014). As the amount of cognitive load increases, the ratio of reproduced duration to actual duration decreases, which means that participants tend to underestimate time (Block, Hancock, & Zakay, 2010). This finding is explained by the Attentional Gate Model as follows: the attentional gate is down, because the participant is focusing on the difficult task at hand, and therefore more pulses of the pacemaker are missed.

The Simon Task

The Simon task is a spatial compatibility task first described in a paper by Simon & Rudell (1967). The Simon task is a two-choice reaction task and stimulus has relevant (e.g. color) and irrelevant (e.g. location) dimensions. Participants are instructed to respond according to the relevant dimension of the stimulus and not to the irrelevant dimension. The Simon task consists of congruent trials in which the irrelevant dimension is spatially compatible and incongruent trials in which the irrelevant dimension is not spatially compatible.

The first true Simon effect was shown in another study by Simon & Small (1969). The Simon effect is based on the universal tendency to respond faster when stimulus and response location overlap, i.e. the congruent condition (Hommel, 2011).

Joint Action

People frequently perform an action together, which is called joint action. The social Simon task is a joint action paradigm in which participants share a Simon task and respond only to half of the stimuli, e.g., blue or red stimuli, occurring on either side of the monitor, respectively. Interestingly, it has been shown that an individual's actions in the social Simon task are represented in the other person's mind and have an impact on their actions. Therefore, the social Simon task results in the same findings as the individual Simon task, i.e., people respond faster to a stimulus on their side ("congruent" condition) as compared to a stimulus on the opposite side ("incongruent" condition) even if the social Simon task does not necessitate a spatial reference as in the individual Simon task. This construction of a mental representation of each other results in an increase in the amount of cognitive load (Sebanz, Knoblich & Prinz, 2003).

Previous studies have shown that the increase in the amount of cognitive load results in underestimation of time (Block, Hancock & Zakay, 2010) which is in accordance with the Attentional Gate Model.

The present study brings together time perception and the social Simon task in a single study. It will broaden our understanding of how human time perception is affected by the social setting and the nature of this setting.

Hypotheses

Our hypothesis is that subjects' time perception during a task is affected by the social setting of the task. In line with the Attentional Gate Model (Block & Zakay, 2006), we argue that joint settings require more attentional resources than the single setting, since participants co-represent their partners' task, thus leaving less resources for time estimation. Due to social facilitation and attention demands, we expect that subjects will perceive time as proceeding faster during a joint-action task than in a single person task. Furthermore, the nature of the social setting – whether cooperative or competitive – may affect time perception. If subjects experience competitive settings as even more attention-demanding they may perceive time as proceeding even faster during a competitive joint action task than a cooperative one.

Method

Participants

A total of 90 participants (42 males, mean age: 25.90, SD=5.234) were tested in three different groups. The Single Task group (n=30, 14 males, mean age: 26.03, SD=6.206) were tested alone whereas the Cooperative Task group (n=30, 14 males, mean age: 25.03, SD=5.442) and the Competitive Task group (n=30, 14 males, mean age: 26.63, SD=3.819) were tested in dyads. Dyads always consisted of participants from the same gender. Participants were recruited through e-mail invitation. They were undergraduate or graduate students from various METU departments. All participants were right-handed and had normal or corrected-to-normal vision. Before the study, ethics approval has been obtained from METU Human Studies Ethical Committee. All participants volunteered to join the study and no monetary reward was offered for participation or performance, since it might affect time perception (Failing & Theeuwes, 2016).

The Simon Task

A Simon task was performed for three different duration lengths (15, 30 and 45 seconds) which was followed by a time reproduction phase. In the single condition, participants were tested alone and they did all Simon tasks and following time reproductions themselves. In the joint conditions (Cooperative and Competitive) participants performed a social Simon task in which each participant was assigned to a specific stimulus color and response button. The participant on the left side was instructed to use only the 'z' button and respond only to red stimuli whereas the participant on the right side was instructed to use only the '.' button and respond only to blue stimuli. These buttons were chosen because on a Turkish Q-style keyboard they are the furthest apart horizontally. All participants used their right hand index finger to respond in order to achieve the same setting between dyads, since literature in the field suggests that the position of hands during a social Simon task might affect performance (Liepelt, 2014; Welsh, 2009). Stimuli occurred on the left and right side of the screen, randomly.

Participants in all conditions were told that they would receive points for their correct responses in the Simon task. In the single condition they were told that their points would be compared with other participants individually, in the cooperative condition they were told that their points would be calculated as a team and compared with other teams, and in the competitive condition they were told that each participant's points would be compared with the other participant in the dyad.

Time Reproduction Task

Before the reproduction phase begun, participants were informed through a message on the screen that they were going to see a big square in the middle of the screen,

indicating the time reproduction phase has begun. Participants used the same button for the time reproduction phase, depending on the color of the big square, i.e. 'z' for red and '.' for blue.

They were instructed to wait as long as they thought the previous trial has lasted and then press the button to indicate the end of the duration. A message on the screen warned the participants before each time reproduction phase, which stayed on the screen for 2 seconds and the time reproduction has begun automatically afterwards. In the cooperative and competitive conditions, participants were instructed that if the big square was in the color they were responsible for, they were assigned to do the time reproduction. In other words, if it was red, the left participant did time reproduction and if it was blue, the right participant did time reproduction. The order of the color was random and balanced between subjects. Participants in all conditions performed a total of 18 time reproductions (6 of each duration length).

The Questionnaire

After the test, participants were presented with a short questionnaire. The first 5 questions were presented to participants in all social conditions and they were regarding their mood and self-assessment during the trials. The second part of the questionnaire, which consisted of questions 6 to 9, were only presented to participants in the joint conditions and were regarding partner-assessment and social warmth. There was also a 10th question which was different amongst the two social conditions. The participants in the cooperative condition were asked to evaluate the quality of their cooperation whereas the participants in the competitive condition were asked the quality of their competition.

Statistical Analysis

Collected data was analyzed in three different sections: Time Reproduction, the Simon Task and the Questionnaire. For the time reproduction, 3x3 mixed ANOVAs with social task setting (individual, cooperative, competitive) as a between-subjects variable and duration (short, medium, long) as a within-subjects variable were conducted on three dependent measures: Duration Ratio (Reproduced Duration/Objective Duration), Absolute Error/Actual Duration and Coefficient of Variation (*SD*/*Mean*).

For the Simon task, response times for compatible *vs* incompatible trials were analyzed as a dependent measure.

For the analysis of the questionnaire, presented options were given values from 1 to 5, with the most negative option being 1 and the most positive option being 5. The first 5 questions, which were presented to all participants, were analyzed with a One-way ANOVA for the 3 task settings (Single, Cooperative, Competitive). The second part, which consisted of questions 6-10, were only presented to the participants in dual task settings. A One-way ANOVA for the 2 task settings (Cooperative, Competitive) was carried out for each question.

Results

Time Reproduction

The first analysis was performed on Duration Ratios (Reproduced Duration/Objective Duration). The main effect of duration was statistically significant ($F(2,174)=174.64$, $p<.001$, $\eta_p^2=.67$). Simple contrasts revealed that reproduction ratios were smaller for long durations ($M=.48$, $SE=.014$) as compared to moderate ($M=.53$, $SE=.015$) ($F(1,87)=49.93$, $p<.001$, $\eta_p^2=.37$) and short durations ($M=.65$, $SE=.015$) ($F(1,87)=225.26$, $p<.001$, $\eta_p^2=.72$), indicating that long durations were underestimated more than moderate and short durations. There was a main effect of task setting ($F(2,87)=14.59$, $p<.001$, $\eta_p^2=.25$). Helmert contrasts revealed a significant difference when the single task setting was compared to both dual task settings ($F(1,88)=18.30$, $p<.001$, $\eta_p^2=.17$). The reproduction ratios in the dual task settings were smaller ($M=.51$, $SE=.022$) than in the single task setting ($M=.64$, $SE=.027$), indicating that duration was underestimated more by the participants in the dual task settings as compared to the single task setting. Also, the difference between the cooperative task setting compared to the competitive task setting was significant ($F(1,58)=11.42$, $p=.001$, $\eta_p^2=.16$). Reproduction ratios were smaller, hence durations were more underestimated in the competitive task setting ($M=.46$, $SE=.023$) compared to the cooperative task setting ($M=.56$, $SE=.019$) (see Figure 1).

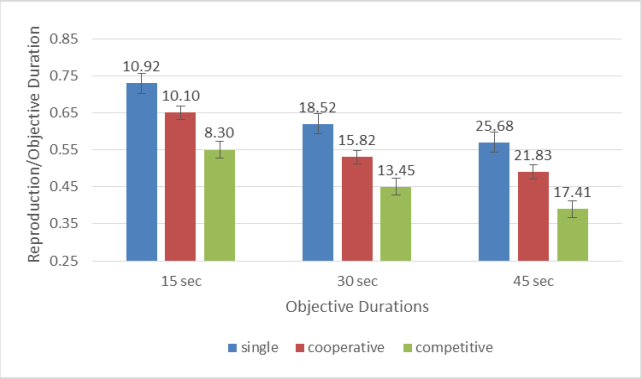

Figure 1: Mean Ratio of Reproduced/Objective Duration across duration lengths for all task settings. (Error bars represent *SE* and the numbers above the bars show the values of absolute time durations)

The analysis of the absolute errors showed that the main effect of duration was significant ($F(2,174)=157.77$, $p<.001$, $\eta_p^2=.64$). Error ratios were higher, indicating that the inaccuracy of participants time estimation was higher in the long duration ($M=.52$, $SE=.13$) than the short ($M=.36$, $SE=.12$) and the medium duration ($M=.47$, $SE=.14$). The setting of the task had a significant effect on accuracy ($F(2,87)=15.38$, $p<.001$, $\eta_p^2=.26$). The first Helmert contrast revealed that participants in both dual task settings showed higher error ratios ($F(1,88)=18.56$, $p<.001$, $\eta_p^2=.17$), hence

were less accurate (M=.49, SE=.018) compared to the single task setting (M=.38, SE=.022). Moreover, as the second Helmert contrast revealed (F(1,58)=11.42, p=.001, η_p^2=.16), error ratios were higher, hence accuracy was lower in the competitive task setting (M=.54, SE=.016) than the cooperative task setting (M=.44, SE=.021). The effect of the interaction between duration and task setting was not significant (F(2,87)=1.45, p>.05, η_p^2=.03) (see Figure 2).

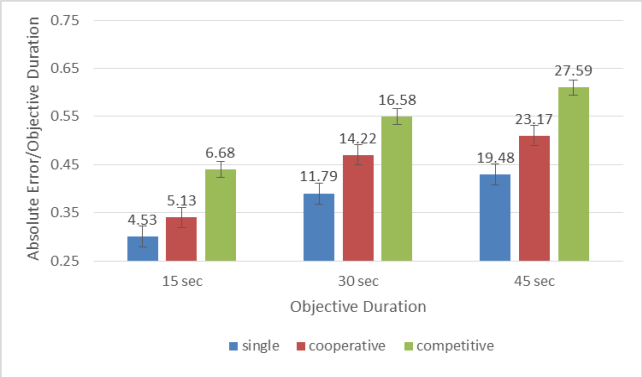

Figure 2: Mean Values of Absolute Error/Objective Duration across duration lengths for all task settings. (Error bars represent *SE* and the numbers above the bars show the values of absolute errors)

The third analysis was carried out on the Coefficient of Variation, which is calculated by dividing the standard deviation of reproduced durations by the mean reproduced durations. The CV is regarded as a very important variable in Scalar Expectancy Theory because a stable CV is a sign of the scalar invariance of subjective estimation of time across different duration lengths (Church & Meck, 2003). The effects of duration (F(2,174)=1.58, p>.05, η_p^2=.02) as well as task setting on the CV were not significant (F(2,87)=2.7, p>.05, η_p^2=.06), indicating scalar invariance, as expected.

The Simon Task

The analysis of the Simon task revealed that congruency had a significant effect (F(1,87)=101.03, p<.001, η_p^2=.54). Response times were significantly shorter in the congruent condition (M=525.66, SE=2.77) in comparison to the incongruent condition (M=533.21, SE=2.79) (see Figure 3). This difference amounts to the "Simon effect". Task setting did not have a significant effect on overall response times (F(2,87)=1.53, p>.05, η_p^2=.03): participants' reaction speed was similar in single (M=535.39, SE=4.29), cooperative (M=529.35, SE=5.79) and competitive (M=523.57, SE=4.18) task settings. The interaction effect between congruency and task setting was not significant (F(2,87)=2.24, p>.05, η_p^2=.05). Participants in all task settings were faster in the congruent condition than in the incongruent condition. Overall, these results revealed that the Simon effect was not affected by the various task settings, indicating that the primary time estimation task did not interfere with the secondary, concurrent task.

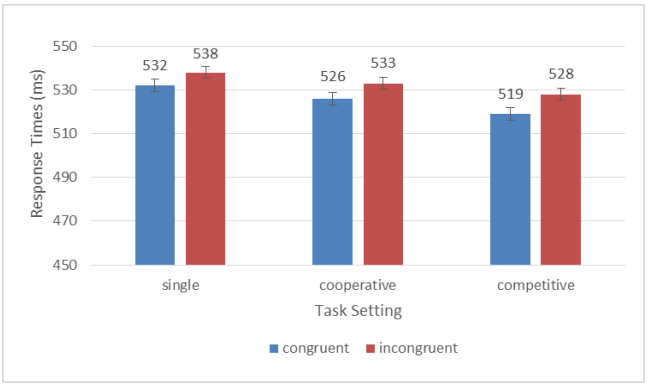

Figure 3: Mean Values of Response Time for congruent and incongruent trials across task settings. (Error bars represent *SE* and the numbers above the bars show mean response times)

In order to assess whether the side at which the participant was seated had any effect on the Simon task, a 2 (Congruency: Congruent, Incongruent) x 2 (Participant's Side: Left, Right) Mixed ANOVA was conducted on response times. Participant's side was a between-subject factor and congruency a within-subject factor. This analysis revealed that congruency had a significant effect (F(1,58)=62.47, p<.001, η_p^2=.52). Participants' response times were significantly lower in the congruent condition (M=522.32, SE=3.58) in comparison to the incongruent condition (M=530.59, SE=3.60). Participant's side did not have a significant effect on overall response times (F(1,58)=0.27, p=.869, η_p^2=.00), i.e., participants' reaction speed was similar on both the left (M=527.05, SE=5.17) and the right side (M=525.87, SE=4.99). The interaction effect between congruency and side was also not significant (F(1,58)=1.00, p=.321, η_p^2=.02). Participants on both sides were faster in the congruent condition than in the incongruent condition, which shows that the Simon Effect was observed in participants on both sides (see Figure 4).

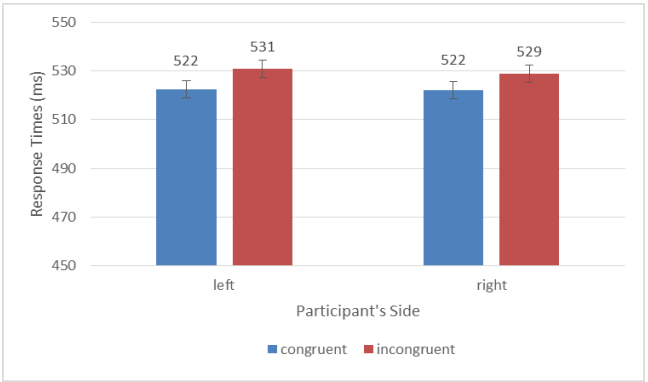

Figure 4: Mean Values of Response Time for participant's side across congruency. (Error bars show *SE* and the numbers above show the values of mean response times)

The Questionnaire

The analysis of the first five questions revealed that main effects were not significant for enjoyment/boredom during the trial ($F(2,87)=.242$, $p=.785$), excitement ($F(2,87)=.079$, $p=.925$), pressure ($F(2,87)=.706$, $p=.496$), self-assessment for the Simon task ($F(2,87)=1.375$, $p=.258$) and self-assessment for the time reproduction task ($F(2,87)=1.457$, $p=.239$).

The analysis of the second part of the questionnaire revealed that main effects were not significant for questions 6 to 9: partner-assessment for the Simon task ($F(1,58)=0$, $p=1$), partner-assessment for the time reproduction task ($F(1,58)=.887$, $p=.350$), friendliness towards partner ($F(1,58)=.267$, $p=.526$) and social warmth ($F(1,58)=0$, $p=1$).

The results of the 10th question on the quality of their cooperation/competition, revealed a significant main effect ($F(1,58)=10.401$, $p=.002$). Participants in the Cooperative task setting assessed their cooperation with a higher value ($M=3.83$, $SD=.87$) than participants in the Competitive task setting assessed their competition ($M=2.90$, $SD=1.32$). This means that cooperative dyads reported to feel more as a team, compared to competitive dyads which reported to feel more as rivals.

Discussion

The results of this study show that there is a strong relation between the social setting of a concurrent executive task and the subjectively perceived duration. Participants estimated the actual duration of the task to be shorter in the joint task settings compared to the single task setting. Also, the nature of the joint action had an impact on the amount of this underestimation, as participants in the competitive task setting underestimated time more in comparison to the participants in the cooperative task setting. These findings are in accordance with previous studies (Dolk et al., 2011; Ford & Aberdein, 2015; Vesper et al., 2011; Vlainic et al., 2010) showing that joint-action tasks affect cognitive performance. In these studies, the effect concerned their behavior in the Simon task, where a social Simon effect occurred. In our task, however, the social Simon effect is not in the focus of our attention. We were primarily interested in the effect of joint action on the primary task, i.e., the time perception task.

The underestimation of the actual duration can be explained with the Attentional Gate Model (Block & Zakay, 2006). Previous studies (Sebanz, Bekkering, & Knoblich, 2006; Sebanz, Knoblich & Prinz, 2003) have shown that when two or more people are performing a task together, they need to create a mental representation of their partner's part of the task, which requires attentional resources to be shifted towards this demanding task. Additionally, participants in the joint task settings had higher cognitive load due to inhibiting their response when the stimulus on the screen was the color of their partner and it was a no-go trial for them, whereas participants in the individual task setting always had a go-trial since they responded to both colors, and only had to keep track of which button to respond. This means that participants in the joint task settings also had an increase in cognitive load caused by task switching. Furthermore, participants in the joint task settings had to monitor their partner's responses as well, since their score contributed to the outcome in dual conditions.

Since cognitive load is high and attention is focused on both the executive task and the mental representation of the partner in dual task conditions, the Attentional Gate is low, i.e., little attention is left to keep track of time, which results in a shorter experienced duration. The attention-depleting effect of executive tasks and the underestimation caused by it is well documented in the literature (Block, Hancock & Zakay, 2010; Duzcu & Hohenberger, 2014). Here, we have shown that also the social task setting affects this attentional mechanism.

Another possible explanation for the decrease in time estimation observed in the social task settings in comparison to the single task setting might be the effect of the "switch" part of the Attentional Gate Model which determines when attending to the passage of time starts and ends. It might be that when the participant is not acting herself but the partner is acting, these parts are "cut out" of her time experience by the closing of the switch. The switch would only open again when it's the subject's turn again. However, it is not possible to explain the difference between cooperative and competitive task groups with this explanation whereas the difference in cognitive load can explain both results.

Previous studies in the field (Decety et al., 2004; Ruissen & de Bruijn, 2016) showed that, although both cooperation and competition result in self-other integration, participants in the competitive condition also spend attentional resources on keeping track of the differences between themselves and the other participant in the dyad. Participants in our study had to manage different cognitive loads according to the social condition: Cooperative dyads only needed to follow their cumulative scores, but participants in the competitive condition needed to follow their performance and their partner's performance as separate information, in order to predict who was more successful. This results in a higher cognitive load and thus more severe underestimation of time.

The literature (Droit-Volet & Gil, 2016; Droit-Volet & Meck, 2007) suggests that mood has a certain effect on time estimation. However, our questionnaire did not reveal any difference in participants' mood during the experiment, despite the significant contrast in their time estimation. This result suggests that the underestimations were caused by the depletion of attentional resources rather than by the effect of mood on the pacemaker.

Our results have also revealed a significant congruency effect in the Simon task, individual and social, which is in line with the vast literature on the Simon task (Hommel, 2011). The results also indicated that there was no difference in reaction times between participants who were seated on the right side and the left side, which shows that seating did not have any effect on participants' performance.

Conclusion

The results of this study provide first evidence that social condition affects time estimation: people perceive time to flow faster when they are performing a task with someone in comparison to when they are alone, and even faster when the nature of the social condition is competitive rather than cooperative. This finding can be applied to daily life in education and at the workplace, by supporting joint action over individual work. Our findings also add to the growing literature on "joint action" (Sebanz, Bekkering, & Knoblich, 2006), showing that there is a strong link between cognitive and social processes. This study has methodological implications in terms of promoting the use of joint settings in cognitive science.

For future studies, experiments that feature another task with similar cognitive load but no social setting would provide information in order to distinguish between the effect of cognitive load and the effect of sociality on time perception. Also, different social manipulations on the same task can provide further explanation whether the difference in time perception is the result of the attentional gate, the switch or the arousal.

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