The Clock Ticking Changes Our Performance

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Abstract

We examined influence of a clock ticking on task performance using a laboratory experiment. We determined performance at various clock speeds using a trick clock that allowed us to control the speed of the ticking. We found that the subjects' performances were influenced by the speed at which the clock ticked, and people performed more slowly with a slow clock. We demonstrated that common environmental stimuli we encounter in life, such as the ticking of a clock, have a significant effect on human behavior.

Introduction

We are exposed to various stimuli, and exogenous stimuli have a number of effects on our behavior. There are many studies address the relationship between music and task performance. Davidson and Powell (1986) focused on the influence of the existence of background music, and found that auditory stimulus affects task performance. They performed an experiment using elementary school students, and found that the class exposed to background music had improved quiz scores. Lesiuk (2005) also found the existence of music improves work performance. They revealed the effects of music on work performance by collecting the data of actual workplace over five weeks. In their study, the quality of work was lowest with no music, and time-on-task was longest when music was removed. They also reported that listening music brings positive mood to workplace, and enhanced perception in working. However, Moller (1980) measured the arithmetic performance with music, noise and silent and showed no significant difference. Liu (2012) sums up that the actual effect depends on the music types (popular or classical), task types and subjects' preferences.

McElrea and Standing (1992) focused to tempo as a musical characteristic, and reported that the task performance is improved with fast music than with slow music. Nittono et al. (2000) pointed out that the experiment of McElrea and Standing (1992) had not enough controlled. They examined the effect of tempo conducting the four conditions: fast and slow classical music, fast and slow metronome tones. They found the performance time was shorter in the fast music than in the slow music, while there is no tempo effect in metronome conditions. Therefore, they concluded that the effect of musical tempo on performance speed is mediated by some other musical factors than tempo.

Then, how about more common sound? It seems few studies investigated the influence of sound not music. In this study, we examine how common stimuli to which we pay little attention influence to our performance. We use the sound of a clock ticking as a common stimulus. We examined this influence using laboratory experiment, but we provided the subjects with no explanation regarding time or the clock, such as "Solve this problem as quickly as you can." Therefore, we can capture the influence of a stimulus that people are not aware of.

Recently, psychological studies addressing task performance have attracted the attention of labor economists seeking to improve employee productivity. Few studies concern the influence of the exogenous environment on task performance; however, this topic is important because the influence of environmental factors is related to the design of an optimal workplace environment.

An academic attempt to change human behavior using something that is easy, simple, and low cost called "Shikakeology." Matsumura (2012) said, "Shikake is a Japanese word that represents physical and/or psychological mechanism that triggers implicit or explicit behavior change to solve problems." This study aims to examine the impact of a simple trick, clock ticking, and it can be considered an example of "Shikake."

Method

Subjects

The participants in our experiment are 36 students (22 males and 14 females) including 10 subjects who lack experience with dot-to-dot pictures. The average age was 20.51 (SD = 1.82). The experiment was held from February 9 to 16 of 2009 at Osaka University.

Conditions

We designed three conditions within subjects; the speed of the clock in the laboratory was set to be (1) fast, (2) normal, or (3) slow. In the fast condition, the speed of clock was 20% faster than a normal clock, producing 60 ticks in 49.98 seconds. In the slow condition, the speed of clock was 20% slower, producing 60 ticks in 72.00 minutes. In the normal condition, the clock was set to the normal speed of 60 ticks in 60 seconds. The order of the conditions and pictures were counterbalanced between subjects.

Materials

Subjects were told to complete a dot-to-dot picture in each session. A dot-to-dot picture is a game in which dots are connected in the order denoted by the numbers beside the dots. The reason that dot-to-dot pictures were selected as the experimental material is that there is less improvement through learning and less heterogeneity in ability across subjects than calculation or memory problems. We attempted to ensure that the difficulty levels of the three pictures were as similar as possible. The pictures used in this experiment have 202 dots, 213 dots, and 221 dots. The number of the last dot is displayed above the picture. Figure 1 shows one of the pictures.

We created a trick clock by implanting an Arduino microcomputer inside of the clock. The trick clock was connected to a notebook computer by a USB connecter, and the experimenter controlled the speed of the ticking using the keyboard. Once the experimenter confirmed the condition, the speed of the ticking began to change in increments of 0.01 minutes and reached the speed required for the experimental condition approximately one minute later. We constructed the face of the clock, and it appears to be a common clock. Figure 2 displays our trick clock.

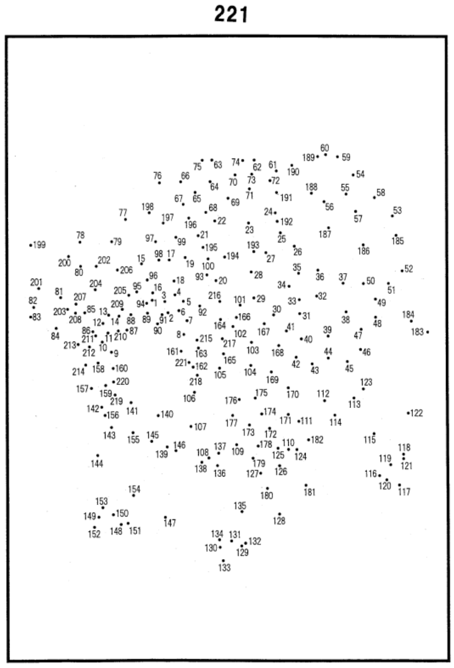

Figure 1. Dot-to-dot pictures used in our experiment.

Figure 2. Photo of our trick clock.

Procedure

The experiment was held in a quiet and unfrequented room. We turned off the air conditioner and maintained quiet conditions throughout the experiment. A video camera was placed behind the subject.

First, the subjects were provided with an explanation of the experiment, including how to complete the dot-to-dot picture. The experimenter provided no description of the clock on the desk and no instructions regarding time such as “solve this puzzle as quickly as you possibly can.” The aim of the experiment was withheld from the subjects until the experiment was over. Therefore, the instructions given to the subjects at the beginning of the experiment took the form of the following cover story: “We aim to measure your posture when you solve the puzzle. So we will film you with a video camera.” In addition, to make the subjects remove their watches, the experimenter told them the following: “it is not good to carry something that adds weight to one side of the body, so please remove your watch, wallet, or mobile phone and put them in this basket.” The basket containing the subject’s watch, wallet, and mobile phone were placed behind the subject. The true aim of the study and the true measurement being made were explained to the subjects after the experiment was over. The subjects were told that they would receive a fixed reward, 1500 yen, when the experiment was finished, but that there would be a penalty if the dots were connected out of order. One mistake reduced the subjects’ rewards by 100 yen.

After the instructions were provided, the subjects completed a practice session. The puzzle in the practice session was easy, with 41 dots. Most subjects finished the practice session within two minutes. The experimenter set the speed of clock, and the first condition began after the practice session. In each session, the puzzle was handed to the subjects face down, and each subject could start whenever he liked by flipping the puzzle over. While the subject was working, the experimenter was seated far enough from the subject to ensure that the experimenter would not distract the subject. The subject informed the experimenter when he finished connecting the dots. After the first session, the experimenter reset the speed of the clock while subjects were given approximately two minutes rest.

When the three sessions were over, the subjects were asked to complete a questionnaire. This questionnaire asked questions regarding subjective performance, subjective difficulty, the degree of awareness regarding the ticking, and their emotional state during the sessions. Each subject was told to assign numbers to the three pictures based on how long he felt it had taken to complete them. Therefore, the subjective performance score for a picture took a value of 1 if the subject responded answered that he had completed this picture the fastest, 2 if second fastest, and 3 if slowest. Similarly, subjective difficulty is measured by the number that subjects assigned to the pictures to rank their difficulty. Subjective difficulty took a value of 1 if the subject responded that he found this picture the most difficult, 2 if it was the second most difficult, and 3 if it was the easiest. In addition, the subjects were asked the following question for each picture: “Were you conscious of the sound of ticking when you worked on this picture?” We employed this answer as the degree of awareness regarding the ticking of the clock, which took a value of 4 if “I was very conscious of the ticking,” 3 if “I was conscious of the ticking,” 2 if “I was not particularly conscious of the ticking” and 1 if “I was not conscious of the ticking at all.”

Results

Measurement

We measured the time each subject took to complete a dot-to-dot picture using the video recorded during the experiment. Completion time was defined as the time beginning when the subject flipped the paper face up to when he connected the last dot. The reason for beginning the measurement when the picture was flipped over is that the subject begins to search for the first dot at the moment he sees the picture. Some subjects checked their lines before they contacted the experimenter, but we did not include that time in the completion time.

Descriptive statistics

Figure 3 presents the average times by condition, puzzle, and session. Based on a one-way ANOVA, there are no main effects of ticking speed ($F(2, 104) = 0.57$, n.s.), puzzle ($F(2, 104) = 0.75$, n.s.), or learning ($F(2, 104) = 2.30$, n.s.) on average time. Next, Figure 4 presents the average time by sex, experience with dot-to-dot pictures, awareness of the clock ticking, subjective performance, and subjective difficulty level.

The average time for males was 7.49 minutes, and that of females was 8.52 minutes. Females required significantly more time to complete the dot-to-dot pictures than males ($t(105) = 2.53$, $p < .05$). The average time for subjects who had some experience with this task was 7.68 minutes, and that of subjects lacking experience was 8.44, but this difference was not significant ($t(105) = 1.70$, n.s.). The subjects who were aware of the change in the ticking speed had an average time of 8.17 minutes, while those who were unaware took an average of 7.83 minutes ($t(105) = -0.651$, n.s.).

On the questionnaire, the average time of the session that subjects ranked as their best performance was 7.67 minutes, that of the second best session was 7.74 minutes, and that of the worst was 8.26 minutes. The results of the one-way ANOVA were not significant ($F(2, 104) = 7.50$). Additionally, the average time for sessions that subjects reported being most difficult was 8.20 minutes, that of the second most difficult session was 7.96 minutes and that of the easiest was 7.51 minutes. The results of the one-way ANOVA were also not significant ($F(2, 104) = 0.87$, n.s.). We also determined that the average time for the sessions in which the subjects reported that “I was very conscious of the ticking" was 8.44 minutes (25 observations), those for which "I was conscious of the ticking" was 8.77 minutes (30 observations), those for which "I was not particularly conscious of the ticking" was 7.87 minutes (39 observations) and those for which "I was not conscious of the ticking at all" was 6.28 minutes (13 observations). The more aware the subjects were of the clock ticking, the longer the time they took to complete the picture ($F(3, 103) = 9.12$, $p < .000$).

Table I reports the correlations between time and the number of sessions, subjective performance, subjective difficulty, and the degree of the awareness of the clock ticking. There was no noticeable correlation, although there was a little the time taken to complete and the degree of concern toward the clock.

Next, we test the influences of the speed of the ticking, the puzzle, and learning effect on the subjective variables (subjective performance, subjective difficulty, and the degree of awareness regarding the clock). There was no significant influence of the speed of the ticking on the subjective variables: the F statistic for subjective performance was $F(2,105) = 1.54$, that of subjective difficulty as $F(2, 105) = 0.37$, and that of awareness of the clock was $F(2,105) = 0.01$. The influence of the puzzle on the subjective variables was also not significant: the F statistic for subjective performance was $F(2,105) = 1.16$, that of subjective difficulty was $F(2,105) = 0.29$, and that of awareness of the clock was $F(2,105) = 0.01$. However, the learning effect had a significant influence on subjective performance ($F(2,105) = 10.91$, $p < .001$) and subjective difficulty ($F(2,105) = 4.39$, $p < 0.05$). Subjects tended to believe that they performed well and the task seemed easier in later sessions. There was no learning effect with respect to being aware of the clock ticking ($F(2,105) = 1.1$, n.s.).

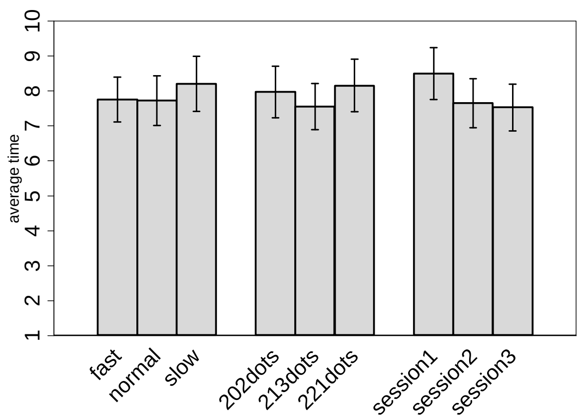

Figure 3. Average time by the speed, problem, and session.

Table 1. Correlations

	Time	Session No.	Speed	Subj. diff.	Subj. perf.	Awareness of ticking
Time	1.00					
Session No.	-0.19	1.00				
Speed	0.09	0.00	1.00			
Subjective difficulty	-0.13	0.14	-0.04	1.00		
Subjective performance	0.12	-0.39	-0.14	-0.04	1.00	
Awareness of ticking	0.41	-0.14	-0.08	0.06	0.18	1.00

Regression

Although the main effect of clock speed was insignificant, it included the effects of the other variables. To isolate the effects of the speed of the clock speed, we performed a regression. We employed a panel fixed effects model.

Table II reports the results of the regression. Panel A of Table II shows the result using the speed of the ticking measured on an ordinal scale: 1 = fast, 2 = normal, and 3 = slow. Column 1 reports the results of a simple linear regression, and column 2 shows the results including learning effects, heterogeneity across problems, and the subjective variables. The puzzles used in the experiment are included in the estimation as dummy variables. For example, "213 dots picture" is a dummy variable that assumes a value of 1 if the puzzle is 213 dots and 0 otherwise. In both models, the speed of the ticking was significantly positive. Subjects were able to complete the dot-to-dot pictures faster with high-speed ticking. Panel B in Table II presents the results using a dummy variable for the speed of the ticking. The "fast dummy" equals 1 under the fast condition and 0 otherwise, and the "slow dummy" equals 1 under the slow condition and 0 otherwise. The normal condition was used as a benchmark. The slow dummy was significantly positive in all models. Subjects required additional time to complete the picture with slow ticking than with normal ticking. As the fast dummy was not significant, we found that fast ticking did not influence the subjects' performance.

There are other variables that affect performance. One is the learning effect; the more sessions a subject participated in, the better his performance. The subjects completed the picture with 213 dots significantly faster. In addition, subjects required additional time to complete pictures for which they provided the response: "it is difficult."

Table 2. The estimation results with individual fixed effects.

Panel A

	Speed only		Including control variables	
	Coef.	**p value**	**Coef.**	**p value**
Ticking speed	0.237	[0.070]*	0.284	[0.009]***
Session No.			-0.398	[0.001]***
213-dot picture			-0.453	[0.034]**
221-dot picture			0.148	[0.472]
Subjective performance			0.127	[0.284]
Subjective difficulty			-0.306	[0.005]***
Awareness of ticking			0.172	[0.357]
Constant	7.418	[0.000]***	8.159	[0.000]***

Panel B.

	Speed only		Including control variables	
	Coef.	**p value**	**Coef.**	**p value**
Fast dummy	0.007	[0.980]	-0.109	[0.618]
Slow dummy	0.474	[0.061]*	0.453	[0.037]**
Session No.			-0.400	[0.001]***
213-dot pictures			-0.447	[0.036]**
221-dot pictures			0.151	[0.464]
Subjective difficulty			-0.293	[0.008]***
Subjective performance			0.146	[0.227]
Awareness of ticking			0.121	[0.535]
Constant	7.727	[0.000]***	8.671	[0.000]***

Note: *** 1%, ** 5%, * 10% significance levels. The dependent variable is the amount of time taken to complete the picture. The subjective performance took a value of 1 if the subject reported that he could complete this picture fastest, 2 if second fastest, and 3 if slowest. The subjective difficulty took a value of 1 if the subject reported that he felt this picture was the most difficult, 2 if second most difficult, and 3 if easiest. Awareness of the clock ticking was a 4 if subjects answered "I was very conscious of the ticking when I was working on this picture," 3 if "I was conscious of the ticking," 2 if "I was not conscious of the ticking," and 1 if "I was not conscious of the ticking at all."

Discussion

In this study, we examined the influence of a fast and slow ticking clock on performance. We designed a laboratory experiment and found that an external stimulus, the clock, can influence performance. We found that slow ticking reduced performance, while fast ticking had no influence when controlling for the other factors.

There are two possible explanations for our results. First, we are unconsciously habituated to a clock ticking 60 times in 1 minute. In our experiment, this familiar stimulus had changed. This change could have had a negative effect on the subjects' performance. To examine this hypothesis, we should conduct the same experiment using children who have not been habituated to hearing the usual speed at which a clock ticks. The other possible explanation is that the rhythm of the ticking may influence the subjects' internal clocks, and this change in their internal clocks affects their performance. The internal clock model (Gibbon, 1977) argues that there argues that the pulse is produced by an internal pacemaker. There are many studies on the internal clock model in psychology, biology, and neuroscience; however, there has been no study on how changes in the internal clock influence human behavior.

We demonstrated the impact of a nearby stimulus on which the subjects' attention was not focused. The contribution of our study is that it demonstrates that making small changes to a common stimulus can easily change human performance. This study is an important first step in Shikakeology. Because the ticking of the clock can be considered to be a small "Shikake," we demonstrated that this Shikake can change human behavior. The aim of Shikakeology is to discover small and simple Shikakes that solve social problems by changing human behavior. Our stimulus, the ticking of a clock, is an appropriate "Shikake" because it is very small, simple, and common. We have successfully shown that this small Shikake can affect performance.

Our results could be applied to the workplace. Work accuracy might be improved when the pace of work becomes slow as Koyano (1985) showed. Koyano (1985) found a correlation between pulse rate and the number of mistakes a person made. He showed the speed of a rhythm influences performance quality. Although future studies are needed, managers should consider whether a task requires a quantitative or qualitative improvement and create a more suitable environment.

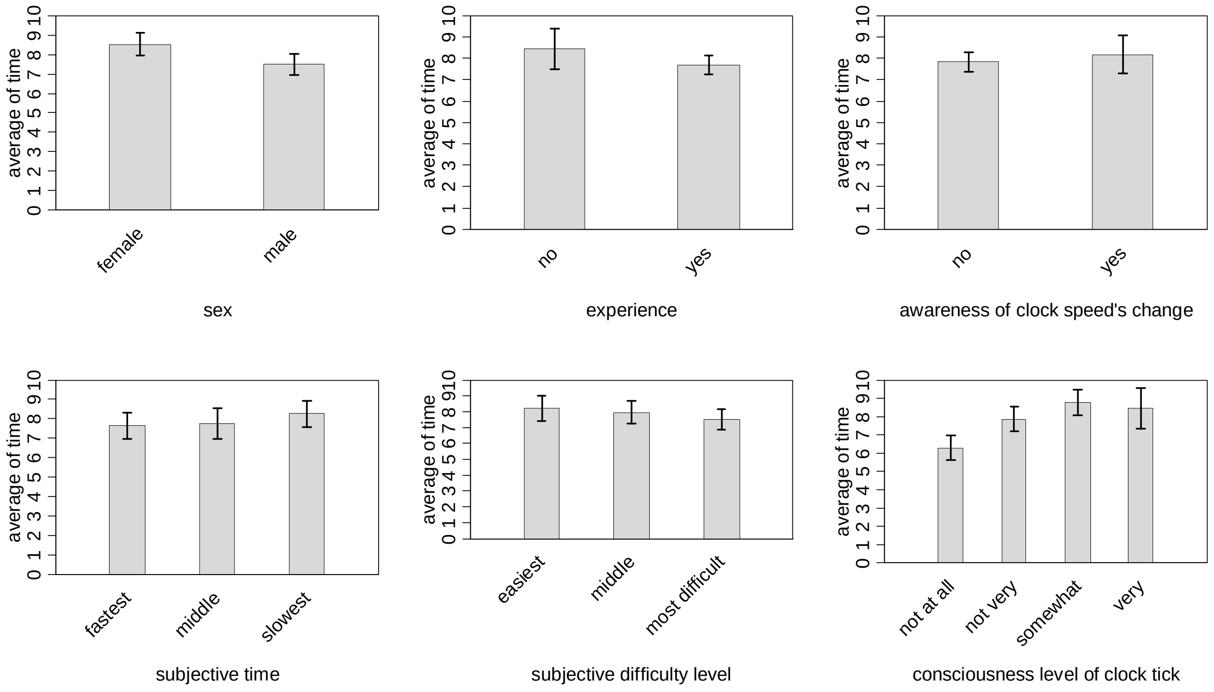

Figure 4. The average time by individual variables.Vertical line is average time (minutes).

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