Intelligent Human Systems Integration (IHSI 2023), Vol. 69, 2023, 168–174
https://doi.org/10.54941/ahfe1002834

The Influence of Worker's Motivation on Intellectual Concentration by ACT-R Cognitive Models

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ABSTRACT

This study examines the influence of worker's motivation on the intellectual concentration performances. An ACT-R cognitive models were adapted in this study to define the details of cognitive process. From the results of controlled participant laboratory experiment shows that the worker's motivation affected the intellectual concentrations. In the high motivational conditions, participants performed faster while answering the task compared to the neutral condition. Two distinguished eye gaze movement patterns captured which indicating the different individual's strategy in a certain condition and time duration. The results from this study might benefit future research on cognitive science in respect of different individual's strategy and motivation.

Keywords: ACT-R, Worker's motivation, Intellectual concentration, Cognitive models

INTRODUCTION

The purpose of this study is to examine the worker's motivation effect on intellectual concentration by an experiment and a cognitive process simulation. By utilizing the adaptive control of thought-rational (ACT-R) concept, it helps to understand the cognitive models of the different motivational condition. ACT-R is one of the prevalent cognitive architectures that mainly differ the cognitive process into production modules and declarative modules (Anderson, 1996; Anderson et al., 2004; Ritter et al., 2018).

Motivation constitutes the composed of psychological mechanism performed by individuals or groups to appoint a certain behaviour and endure with it (Mclnerney, 2019). Several theories describe the human's motivational concept such as the self-determination theory which distinct the intrinsic and extrinsic motivation (Deci and Ryan, 2000). Some paramount aspects of the human's motivation could helps describing the various human demeanor, differences on individual characteristics to completing the works, and conjecture on the variety of the learning process (Lafrenière et al., 2012; Peters et al., 2018; Shahri et al., 2020). Therefore, in the study to investigate the intellectual performance, it is also important to considering the individual's motivation.

Several studies have been investigating the human cognitive performance in respect of others factors such as working environments (Kitayama et al.,

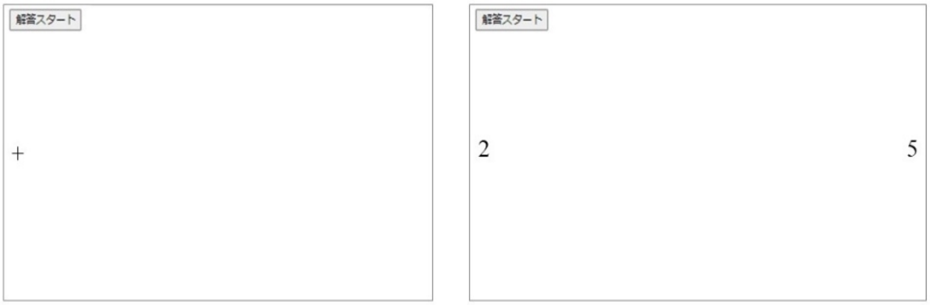

Figure 1: Task screen monitor.

2022; Ueda et al., 2022b, Ishii et al., 2018, Ueda et al., 2017) and utilize the index of concentration ration (Ueda et al., 2022a; Yamamoto et al., 2021). Inspirited by previous studies, this study has explored the human motivational factors that might influence intellectual concentration. Additionally, exploring the differences in workers' individual problem-solving strategy is one of the alluring factors in this study given the differences in motivational conditions.

METHODS

Five participants were recruited for the experiment in which the range of their ages were between 18–22 years old (mean = 23,2 years old, male = 3) as a pilot study. The simple summation mathematical task was given during the experiments. At first, the plus sign appears on the left side and participants were instructed to look at the sign. Secondly, two digits appear on the left side and right side of the monitor screen. Figure 1 shows the task screen. They were asked to answer the first digit of the summation of the two digits by pressing the numerical keyboard and the answering time was automatically recorded on the experiment program. They were asked to repeat to answer the above summation task.

The cognitive mechanism of the user's performance is elucidated by the ACT-R concepts which mainly classifies the models into procedural and declarative knowledge (ACT-R Software, 2019). The eye gaze movements were recorded and analyzed during the experiments by utilizing OpenFace software (OpenFace, 2022) and video playback by QuickTime Player program (QuickTime Player, 2016). The eye gaze pattern movement were extracted from the output of OpenFace data which contain the horizontal axis eye movement. In the horizontal axis eye movements, the positive numbers indicate the gazing movement to the right side, and vice versa.

In this study, the participants performed the task under two different motivational conditions. The first condition was set to create the urge to finish the task immediately which generates high motivation to finish the task as fast as they could. The other condition was set in a neutral condition which the participants could perform at their own pace without a rush. The design

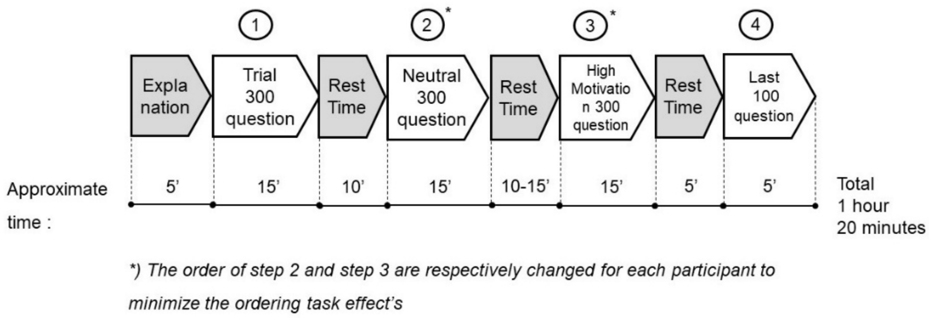

Figure 2: The design of experiment procedures.

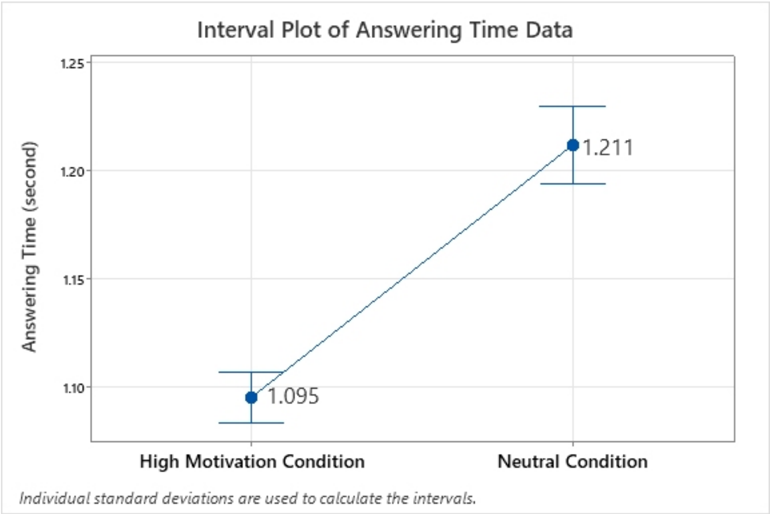

Figure 3: The interval plot of answering time in a high motivational condition and neutral condition.

of the experiment is shown in Figure 2. From this experiment, approximately 3000 answering time data and 900.000 frames of the eye gaze movement were collected and analyzed.

RESULTS

The different motivational conditions influenced the user's task performance. Paired samples t-test showing a statistical difference in the user's answering time between high motivational and neutral conditions ($p < 0.01$). Figure 3 shows the interval plot of answering time data in a high motivation condition and neutral condition. The distribution of the answering time seems to follows the log-normal distribution shapes shown by both conditions as shows in Figure 4.

The participants performed different strategies in the cognitive task. Following the ACT-R modules, in general, the identified eye gaze patterns are divided into 2 patterns. Utilizing the eye gaze movement patterns and

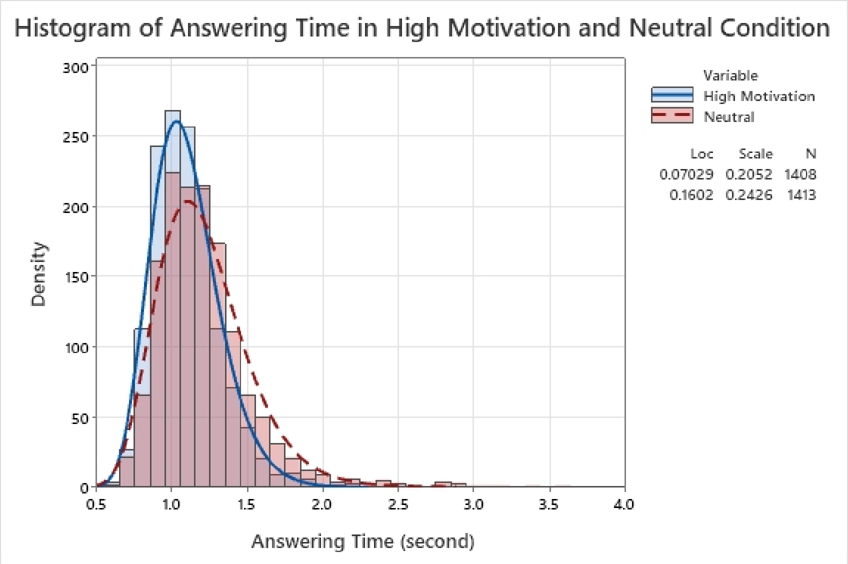

Figure 4: The distribution of answering time in a high motivational condition and neutral condition.

determining the answering time, helps to differentiate the individual's strategy for gazing the eye moves back to the first place then performed the answering acts or do the answering acts then return the eye gaze to the first place. Each pattern is distinguished based on the production rules formed in the ACT-R programming modules. In the first pattern, the participants' cognitive process follows the process states starting from (a) finding the number on the left side of the screen and then memorizing the left side number, after that (b) the participants alter the gaze into the right side to find the second number and memorize it, then (c) the eye gaze moved back to the left side again, and finally (d) the participants pressing the numerical answering keyboards. The ACT-R production rules code for the first patterns translated into (1) find-left-number, (2) attend-left-number, (3) encode-left-number, (4) retrieve-left-number, (5) find-right-number, (6) attend-right-number, (7) encode-right-number, (8) waiting-for-start-back, (9) attend-start-back, (10) summation, and (11) keyboard-click. Figure 5 shows the first pattern examples.

On the other hand, the second eye gaze patterns follow the stages start from (a) finding the number on the left side and then memorize the number, next (b) shift the gaze to the right side to find the second number and memorize it, subsequently (d) the participants push the answer's keyboard, and then (c) the participants look back on the left side again. The second pattern written in code of the production rules such as: (1) find-left-number, (2) attend-left-number, (3) encode-left-number, (4) retrieve-left-number, (5) find-right-number, (6) encode-right-number, (7) summation, (8) keyboard-click, (9) waiting-for-start-back, and (10) attend-start-back. The eye gaze pattern shows in Figure 6.

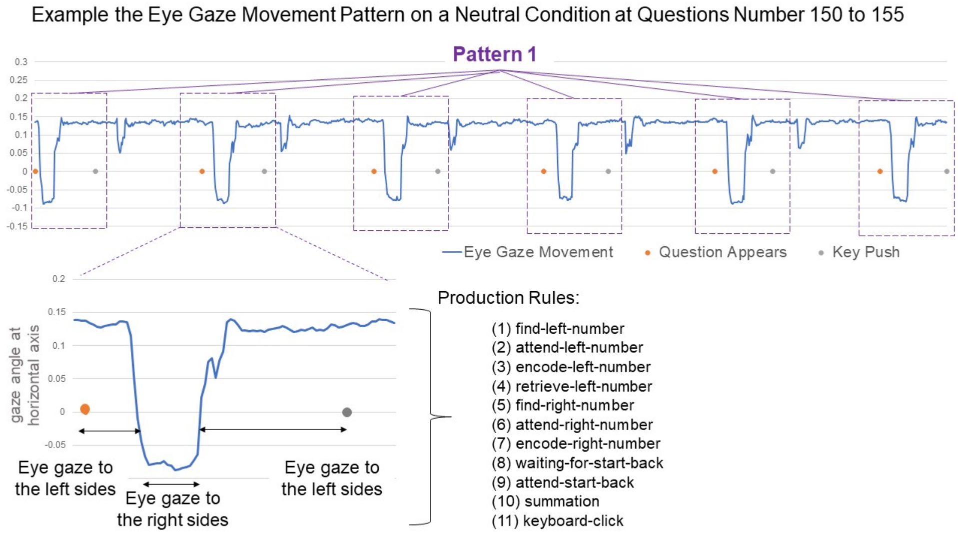

Figure 5: Pattern 1 of the eye gaze movement.

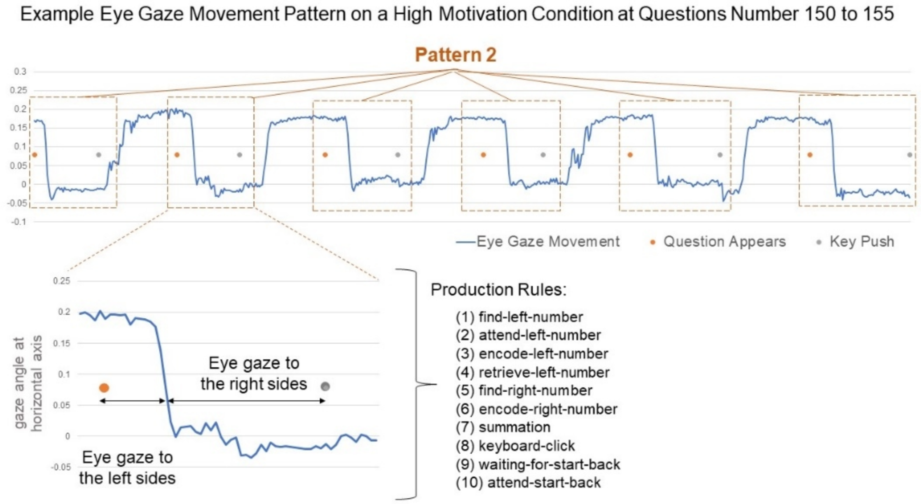

Figure 6: Pattern 2 of the eye gaze movement.

In the different motivational conditions, the pattern's appearance is altered. For participants 1, 3, and 5 the second patterns were dominant during the high motivational condition. Some irregular patterns aroused in the last 5 minutes of the task. In the limited amount of time starting from the appearance of the digits to the keyboard push, the eye gaze movements were going back and forth from left to right which produced the irregular patterns. This condition might due to the degradation of the user's cognitive performance when the participants felt tired and it might be the time duration that affected their cognitive performance. The percentages of the eye gaze patterns in the beginning, middle, and at the end of the task are shown in Figure 7.

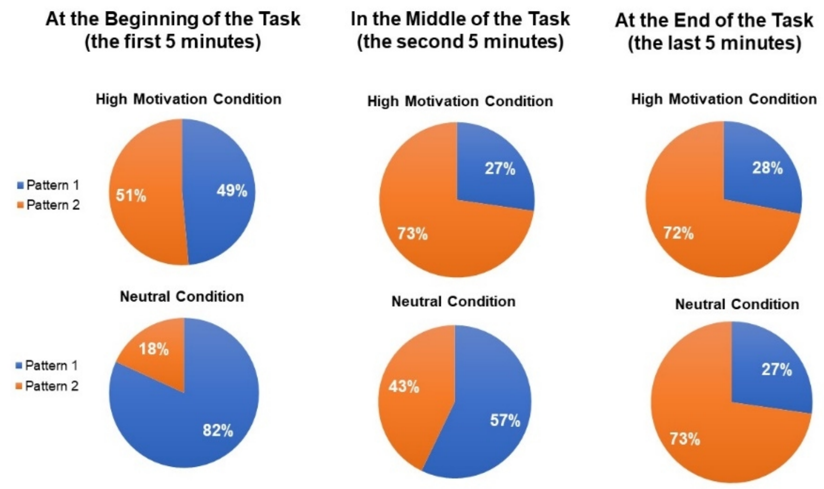

Figure 7: Percentage of the eye gaze patterns appearance during the experiments.

CONCLUSION

In this study, the worker's motivation shows an impact on intellectual concentration. However, further investigation might be needed to explore the significant implication of a greater number of participants recruited.

Subsequently, the individual's different strategy is also an interesting topic to investigate. As resulted in this study that the participants show different strategies under different motivational conditions. Additionally, the duration time of the task might also influence the user to utilize different strategies and the effect of fatigue might influence the result in a long duration of the task.

For future work, creating the ACT-R model and parameters value based on the results of the eye gaze movement analysis might be taken into consideration. Furthermore, developing the advanced ACT-R model has the potential benefit in the development of a robust model for general purposes of cognitive performances.

The results of this study might enlighten future research on cognitive performance by proposing a new method of eye gaze pattern identification on ACT-R cognitive models. It is highly recommended to explore different cognitive tasks and individual's different conditions which might increase the repertoire of knowledge in the field of cognitive science.

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