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HUMAN-AUTOMATION PERFORMANCE UNDER TIME PRESSURE HAS LIMITED BENEFITS

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Previous research by Rice and Keller (2009) has supported that time pressure can positively affect operator compliance with an automated device if the automation is highly reliable despite the impact of speed-accuracy trade-off. When given sufficient time, operators aided by highly reliable automation tended to ignore the aid's recommendation and produced human-automation performance levels less than that of the automation itself. When the operators were put under time pressure, they tended to comply with the automation with a performance that equaled or exceeded that of the automation itself. The current study suggests that the time pressure heuristic is only beneficial when the target is difficult to find by manipulating the time pressure and the difficulty of the search task. The results find that the time pressure heuristic is not as beneficial for easy to find targets as it is for difficult to find targets.

Automation is a helpful tool often used to increase human performance. Wickens and Hollands (2000) denote automation as an entity that has the potential to enhance or replace human performance. It has been found that human performance is lower than the combination of human and automation (human-automation); furthermore, the performance of the automation alone is typically stronger than human-automation (e.g., Dixon, Wickens, & McCarley, 2007; Dixon & Wickens, 2006; Rice, 2009; Rice, Trafimow, Clayton & Hunt, 2008; Weigmann, McCarley, Kramer, & Wickens, 2006). In a more specific case of target detection tasks, human performance was higher when paired with a diagnostic automation than without the aid. Although the performance has been found to increase when the operator is paired with automation, it has also been found to decrease human-automation performance may occur (Breznitz, 1984). This could be attributed to the operator ignoring, second-guessing, or relying too heavily on the automation (Breznitz, 1984).

It is important to look into why human-automation performance is lower than that of automation. One factor that has been found to affect the level of reliance on automation is trust. In many cases, trust in automation is often based on a subjective evaluation on how well the automation will help the operator reach their objective (Lee & See, 2004). However, there are several aspects that effects trust of automation, such as the reliability of the automation itself (Weigmann, 2002). Reliance on automation can be detrimental to performance because the operator may often over-rely on the automation even when it is wrong (Parasuraman, Molloy and Singh, 1993). This can be due to the operator becoming overly content with the automation and disregarding errors. The opposite has also been known to occur if the reliance is low the operator may not use the aid at all (Dixon & Wickens, 2006).

It was found that the different errors in automation cause change in the operator's trust of the automation (Meyer, 2001; 2004; Rice, 2009; Parasuraman & Riley, 1997). These errors are known as false alarms and misses. If the automation is more apt to produce false alarms then the compliance decreases. If the automation is more apt to produce misses, the reliance on the automation decreases (Meyer, 2001; 2004). In some cases the operators may be in situations that include multiple tasks, stress, or penalties for not complying. If these situations exist, the operator may be more willing to depend on the automation. Another situation that could influence the operator's decision-making process is the existence of time pressure (Maule, Hockey & Bdzola, 2000; Maule & Svenson, 1993; Maule, 1997; Maule & Edland, 1997). Further research has shown that an operator under time pressure has less severe judgments that generally lead to better decisions (Kaplan, Wanshula, & Zanna, 1993; De Neys, 2006). By incorporating time pressure, the operator may be able to take into account more essential information that is incorporated into their decision making process (Ben-zur & Breznitz, 1981; Bockenholt & Kroeger, 1993; Kerstholt, 1995; Payne, Bettman, & Johnson, 1988; Wright, 1974).

A study by Rice & Keller (2009) participants was asked to search through aerial photographs for an enemy target with the use of an automated aid. The aid that was used varied between reliability percentages. The participants were assigned to one of two conditions. One condition was set up to create the effect of time pressure by only having 2 seconds with the photograph. The other condition allowed the participants 8 seconds in order to avoid time pressure effects. The results showed that when the participants were under time pressure, their reliance on the

automated aids were higher than the condition of no time pressure. Also, the results were able to demonstrate that the time pressure condition relied on the automated aid regardless of the reliability percentage. Trust did not vary between the two conditions. The performance of the time pressure condition was higher than the other condition when the reliability of the aid was high but was lower when the reliability percentage was low.

In the current study, we will expand upon the original study by Rice & Keller (2009) by manipulating the difficulty of the aerial photographs. We would like to observe the differences of performance between the difficult and easier task when under time pressure. We hypothesized that when the operator is faced with an easy task, the time pressure effects will not be as strong or beneficial as it would be for a difficult task.

Method

Experiment 1

One hundred and sixty (100 females) undergraduate students at New Mexico State University participated in the experiment for partial course credit. The mean age was 20.51 (SD = 2.59). All participants reported normal or corrected to normal vision. The design of Experiment 1 was a recreation of the previous study by Rice & Keller (2009). A 2 x 5 between-participant study was used with time-pressure and automation reliability as the two independent variables. The time-pressure was either speeded or unspeeded. The automation reliability was presented as 100%, 95%, 80%, 65%, or no automation "B". Each participant was randomly selected to one of 10 conditions.

Each participant was presented with 100 photographs of Baghdad (see Figure 1). Fifty of the photographs contained an enemy tank, and the other 50 photos did not. The experiment was conducted on a Dell computer with a 20" monitor using 1024 x 768 resolution via E-Prime 1.1. The participants were seated 21" from the display by using a chin rest to control the position. They were asked to read through the instructions on E-Prime and to press any key once they were ready to begin. The participants were commanded to press the "J" key if they detected a tank. If they determined no tank was present, they were commanded to press the "F" key. The participants were instructed to try to maintain the highest accuracy as possible. They were informed if an automated aid were present to relay recommendations on whether or not an enemy tank was present in the photograph. Depending on which condition the participant was in; they were told the reliability percentage of the aid (100%, 95%, 80%, 65%, no automation) and how much time they had to view the image (2 seconds or 8 seconds) after the recommendation had been given by the automated aid.

Once the experiment began, a slide provided the recommendation of the automated aid for 1000 ms prior to the aerial photograph slide. The recommendation was one of two different messages, "The automation has detected a tank!" or "The automation has determined that there is no tank present!" The aerial photograph was shown for 2 seconds for the speeded condition and 8 seconds for the unspeeded condition. The participants were presented with instant feedback to each response for 1000 ms after each key press. The feedback included whether they were correct (in green letters) or incorrect (in red letters) and current percent of correct answer responses.

Figure 1. A sample image used in the experiment. The tank is located in the top central area to the southeast of the concentric circles.

Results

Figure 2 presents the data from the experiment. For the purposes of data analysis, all accuracy scores were converted to d' measures (signal detection theory). There was a main effect of Condition, $F(4, 150) = 108.18$, $p < .001$, but no main effect of Speeded-Unspeeded (SU), $F(1, 150) = 1.76$, $p = .19$. An interaction between Condition and SU, $F(4, 150) = 5.74$, $p < .001$, revealed that the benefits of the speeded heuristic were limited to the higher reliability levels (100% and 95%). These results replicate those found by Rice and Keller (2009).

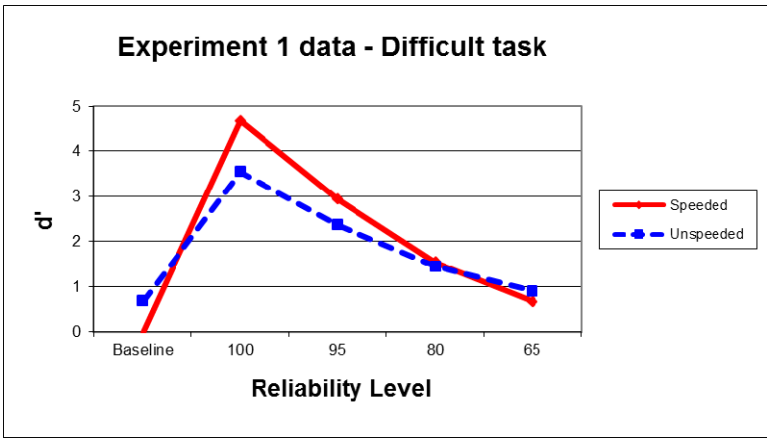

Figure 2. Data from Experiment 1.

Experiment 2

Method

One hundred and forty (100 females) undergraduate students at New Mexico State University participated in the experiment for partial course credit. The mean age was 20.00 (SD = 2.63). All participants reported normal or corrected to normal vision. One participant's data was dropped from analysis due to a corrupted file.

Experiment 2 was identical to Experiment 1 with one exception. Instead of using the images from Experiment 1, new images that were less cluttered were used. A pilot study showed that the targets in these images were easier to find than those used in Experiment 1.

Results

Figure 3 presents the data from Experiment 2. There was a main effect of Condition, $F(4, 129) = 15.70$, $p < .001$, and a main effect of Speeded-Unspeeded (SU), $F(1, 129) = 38.88$, $p < .001$. The interaction between Condition and SU, $F(4, 129) = 1.83$, $p = .13$, was not significant. These data reveal that when the task of finding the tank is easy, then there is no benefit to using the speeded heuristic at any level of reliability.

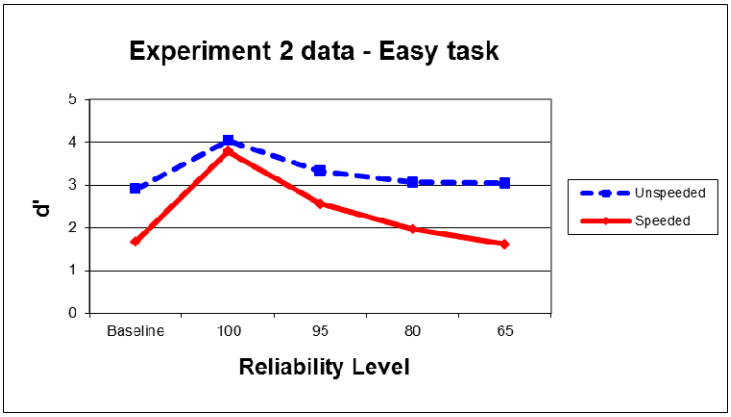

Figure 2. Data from Experiment 2.

Discussion

The purpose of the current study was to extend the findings from Rice and Keller (2009) and Rice and Trafimow (2012), by examining whether the beneficial effects of the time pressure heuristic would remain despite decreasing the difficulty of the task in question. We manipulated both the amount of time participants were allowed to view the aerial images and the difficulty of the search task. We hypothesized that when the task was difficult, time pressure would result in increased human-automation performance, replicating previous findings, but that when the task was easy, the time pressure heuristic would not be as beneficial to performance because participants would perform just as well on their own. The findings from the study showed that our hypotheses were confirmed. When the search task was difficult, the data replicate those from Rice and Keller (2009). However, when the task was easy, the time pressure did not benefit performance, but in fact, decreased performance compared to when there was no time pressure.

The differences between the easy task and the hard task performances could be due to a few explanations. The time pressure heuristic often drives the operator to use the automation in order to make a decision (Rice and Keller, 2009). If the task is easy, the time pressure heuristic may not influence the operator in their decision or use of the automation. In other words, the operator may not feel pressure due to the small amount of time with the photographs and can confidently make a decision without employing the automation. A second explanation could be that the operator is over confident in their decision due to the task being easy. If the operator assumed that they are correct every time, they are less likely to agree with the automation, which then drives down their performance in cases where the automation's reliability is high.

A study by Rice and Trafimow (2012) also expanded upon the Rice and Keller (2009) study by applying the potential performance theory (Trafimow & Rice, 2008, 2009). They were able to analyze the differences between the speeded group and unspeeded group. The observed scores, potential scores, and the consistency scores were all used in order to perform the PPT analyses (Rice and Trafimow, 2012). They were able to show that the time pressure task allowed for a better performance due to the decrease in randomness when making a decision. This could help explain why the easier task had a lower performance. The randomness in the task increases when dependence on the automation decreases. In other words, if the operator had used the automation to make their decision, the randomness would have been lower and the performance higher.

Practical implications can be taken from these newfound results. Since it is known that the automation has the potential to increase performance, it is important to know what factors can influence the operator's reliance and compliance with the automation. If a time pressure heuristic is put into place in the design of such automation and tasks, it is important to know that it will not always increase the performance of the operator if the task is too simple. This should be kept in mind when training and designing automation aids.

Conclusion

The results of the first experiment concurred with the original study by Rice and Keller (2009). Imposing a time pressure heuristic to a task was found to increase performance. The second experiment found that lessening the difficulty of the task decreases the effectiveness of the time pressure heuristic when the automation reliability is high. The easier task decreased the operator's dependence on the automation which in turn decreased performance.

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