Automaticity Training Improves Visual Skill Acquisition in Airport Security Screening

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The acquisition of visual skills in complex time-pressured tasks such as airport security screening is of prime concern to researchers today. The development of effective training strategies is important as this environment is characterized by multiple stimuli and distractors, as well as extraneous variables such as time pressure and workload that challenge performance in the absence of a practiced skill set. In this paper we examined whether "automaticity training" (described below) is an effective method to train security screening personnel in a task typically characterized by high demands for vigilance, varying levels of task difficulty, multiple targets and time constraints.

A classic finding from the dual process theory of automaticity (Schneider & Shiffrin, 1977) is that information processing is more efficient (higher accuracy, faster response times) when stimuli are consistently-mapped to target and distractor categories over a period of extended practice. On the other hand, under varied-mapping conditions wherein stimuli may be targets in one instance but distractors in another, performance occurs under controlled processing, which is voluntary, serial, and requires attention.

Several researchers have attempted to adapt Schneider and Shiffrin's automaticity paradigm to improve visual skills in different contexts. These researchers have demonstrated that consistency in stimulus mapping combined with a small frame size and memory set size, significantly improves response time and performance accuracy in contexts ranging from simple target detection tasks (Fisk & Schneider, 1984; Kramer et al., 1991) to complex tasks involving multiple dynamic stimuli (Gonzalez et al., in review). The primary goal of our research, therefore, was to examine whether automaticity training can be effectively implemented to improve visual skill acquisition in an airport security screening task. In addition to the 'traditional variables' of frame size, memory set size and stimulus mapping, we incorporated time constraint into our paradigm in order to better capture the high levels of workload inherent in luggage screening.

Method

College students (n = 24) completed 800 trials of a luggage screening task. On each trial, participants observed a two-color x-ray luggage-image cluttered with a variety of everyday objects (e.g., clothes, hair dryers, pill bottles) moving from one end of the screen to the other. Each image moved onto the screen from the left, froze for a brief duration in the center of the screen and then continued exiting the screen towards the right. Time constraint was imposed on two levels: (i) in the 'low time constraint' condition, the luggage image took 4 seconds to enter the screen, froze for 4 seconds and took 4 seconds to exit the screen; (ii) in the 'high time constraint' condition, each of the above actions lasted for a duration of 2 seconds instead of 4, thereby increasing the degree of constraint on participants' image-viewing duration.

The images were presented in 16 blocks of 50 trials each. At the beginning of each trial block, participants were asked to memorize a set of targets. Participants were required to make a decision about stopping the bag or not, according to their belief that a member of the memory set was hidden in the bag. After the decision, participants were presented by textual feedback. The target probability was 40% i.e., 20 bags in every block of 50 bags contained a digitally superimposed knife/weapon.

In addition to time constraint and practice, three within-subject independent variables were manipulated:

1) Frame size (FS): One half of the images were 'high clutter' images while the other half was 'low clutter' images. The latter contained approximately 50% of the clutter of objects in the former.

2) Memory set size (MSS): The number of objects in the memory set was 1 or 4.

3) Stimulus mapping (SM): On consistent mapping (CM) trials, the task was to look specifically for knives among miscellaneous objects. On varied-mapping (VM) trials, the task was to detect miscellaneous objects (e.g., a metallic coil, a fork, scissors) among miscellaneous distractors. Furthermore, on VM trials, an object that was a target in one block was a distractor in another block.

We examined the effect of the above factors on: (1) response times, (2) hit rates, and (3) false alarm rates.

Results

Since there were no effects of MSS, SM and time constraint on performance when FS was low, we present the data for highly cluttered images alone.

Response time - time taken (in seconds) for the participant to press the space bar upon detection of a target in the x-ray image. When time constraint was low and coupled with a large MSS, response time on CM trials ($M = 1.4$, $SD = 1.22$) was significantly lower than on VM trials ($M = 2.2$, $SD = 2.1$), $p < .05$. An increase in time constraint, however, diminished the cognitive advantage offered by consistent mapping leading to no significant differences between CM ($M = 2.1$, $SD = 2.22$) and VM trials ($M = 2.6$, $SD = 3.1$), $p = .38$ across both memory loads.

Hit rates. When time constraint was low, hit rates were significantly higher on CM trials ($M = .90$, $SD = .55$) than on VM trials ($M = .75$, $SD= .25$), $p < .05$ across both levels of MSS. However, when time constraint was high, hit rates were significantly higher on CM trials ($M = .92$, $SD = .45$) than on VM trials ($M = .70$, $SD = .67$), $p < .01$, only when MSS was large. Contrary to expectations, hits rates were significantly higher on VM trials ($M = .80$, $SD = .46$) than on CM trials ($M = .75$, $SD = .50$), $p < .05$ when MSS was small.

False alarm rates. At both levels of time constraint, a large MSS led to significantly higher false alarm rates on VM trials ($M = .20$, $SD = .23$) relative to CM trials ($M = .11$, $SD = .45$), $p < .05$; a small MSS did not reveal any differences between CM ($M = .15$, $SD = .67$) and VM trials ($M = .20$, $SD = .84$), $p = .36$.

Conclusions

The results of the present study support our primary hypothesis that contextual variables leading to the development of automaticity in generic visual search tasks also lead to performance improvements in complex tasks such as airport security screening. However, the additional workload generated by time constraint exerted a detrimental effect on skill acquisition by diminishing the cognitive advantage offered by consistent mapping of stimuli. The likelihood of objects in passenger luggage being consistently mapped in the real world is low; yet, the results of the present study suggest that training interventions based on consistent mapping, with low workload are likely to be more effective in skill acquisition that methods based on varied mapping of stimuli with high levels of workload. The applicability of automaticity training interventions in a real world luggage screening context remains to be examined.