Attentional Switch Characteristics are Correlated with the Performance of Simulated Aviation Task

Feng Du(✉), Jie Zhang, and Mengnuo Dai

Institute of Psychology, Chinese Academy of Sciences, Beijing 100101, China
duf@psych.ac.cn

Abstract. The present study explored what attentional switch characteristics are correlated with simulated aviation task performance. We measure the attentional switch characteristics based on three AB indices. When two targets are presented in a RSVP stream, the impairment in identification of the second target (T2) after correct report of the first target (T1) is attentional blink (AB). First, the overall switch cost is the AB magnitude which is the difference between the highest and lowest accuracy of T2 given correct report of T1 (T2/T1) across five T1-T2 intervals. Second, the general cost of processing T1 is measured by the average accuracy of T2/T1 across intervals. Finally, the AB dwell time is measured by the temporal interval when the accuracy of T2/T1 reach the lowest level across five T1-T2 intervals. The Multi-Attribute Task Battery (MATB) is used to simulate aviation tasks. The results show (1) AB dwell time is significantly correlated with the RT of monitoring dashboard; (2) average accuracy of T2/T1 is correlated with the performance of multiple tasks in the MATB including monitoring dashboard, resource management and tracking tasks. These results indicated that several AB indices might be useful for predicting the simulated aviation performance.

Keywords: Attentional switch characteristics · Attentional blink · Multi-attribute task battery · Simulated aviation performance

1 Introduction

When pilots are facing rapidly changing environment and dealing with multiple concurrent tasks in aviation, their cognitive systems are constantly overloaded with information flows. Attentions act as a goalkeeper of cognitive system to select more relevant information to aviation and filter out irrelevant information. Therefore, attentional characteristics of pilots are critical for predicting their aviation performance [1–4].

Since pilots are always facing multiple concurrent tasks in flight, they need to switch between tasks. These task switch usually requires switch in attentional set [5]. Thus the attentional switch characteristics might be a very important predictor for aviation performance. However, few studies examine whether attentional switch characteristics is correlated with aviation performance. Recent studies on Attentional blink shed light on this topic. The attentional blink (AB) refers to people's inability to

C. Stephanidis (Ed.): HCII 2015 Posters, Part II, CCIS 529, pp. 605–609, 2015.
DOI: 10.1007/978-3-319-21383-5_101

detect or identify a second target (designated T2) that follows within about five hundred milliseconds of an earlier target (T1) in the same location [6–8]. Visser and colleagues conducted a meta-analysis of previous AB work and found that the impairment caused by the attentional blink may be greatest away from the previously attended location [9]. This was further confirmed by several recent findings [10, 11]. Furthermore, Du and Abrams found that the benefit of the exogenous cue was reduced if the cue was presented within 100–200 ms after T1, when the attentional blink would be strongest, but it recovered as the interval between T1 and the cue increased [12–14]. Thus, the attentional blink provide a perfect measure of attentional switch characteristics.

2 Method

2.1 Participants

42 participants took part in experiments (25 males). All participants had normal or corrected-to-normal vision (including color vision). The experiment is approved by the internal review board of institute.

2.2 Attentional Blink

We adopt Attentional Blink to assess the attentional switch characteristics. Participants were required to report the two targets embedded in a RSVP stream [6]. After reporting the first target (T1) correctly, participants usually have difficulty in identifying the second target (T2). The impairment for reporting T2 is attentional blink (AB). The attentional switch characteristic were measure based on three AB indices. First, the overall switch cost is the AB magnitude which is the difference between the highest and lowest accuracy of T2 given correct report of T1 (T2/T1) across five T1-T2 intervals. Second, the general cost of processing T1 is measured by the average accuracy of T2/T1 across five T1-T2 intervals. Finally, the AB dwell time is measured by the temporal interval when the accuracy of T2/T1 reach the lowest level among those at five T1-T2 intervals.

The stimuli were displayed on a 17-in. CRT monitor with a resolution of 1024 × 768 pixels at a refresh rate of 85 Hz. The viewing distance is 60 cm. The background is black. Each trial began with the presentation of a fixation cross for 600 ms. The fixation cross was followed by 20 upper-case white letters (1.3° in height) sequentially presented at fixation. Letters were randomly chosen from all letters in the alphabet except the letter I. Each of the letters was presented for 40 ms and was followed by a 40 ms black screen. Thus SOA is 80 ms. The first target, T1, was a white digit randomly chosen between 2 and 9. It could appear in the tenth, eleventh, or twelfth frame in the stream.

The letters continued to change at the same rate after T1 was presented. T2 appeared in the 1st, 2nd, 3rd, 4th or 5th frames after T1. The T2 was a white letter chosen from letter A, B, X or Y. Participants were required to report both T1 and T2 as accurately as possible.

2.3 Multi-Attribute Task Battery (MATB)

We used Multi-Attribute Task Battery (MATB) to simulate aviation tasks [15]. As illustrated in Fig. 1, the MATB have four concurrent tasks including monitoring dashboard, manually tracking a target, verbal communication and resource management.

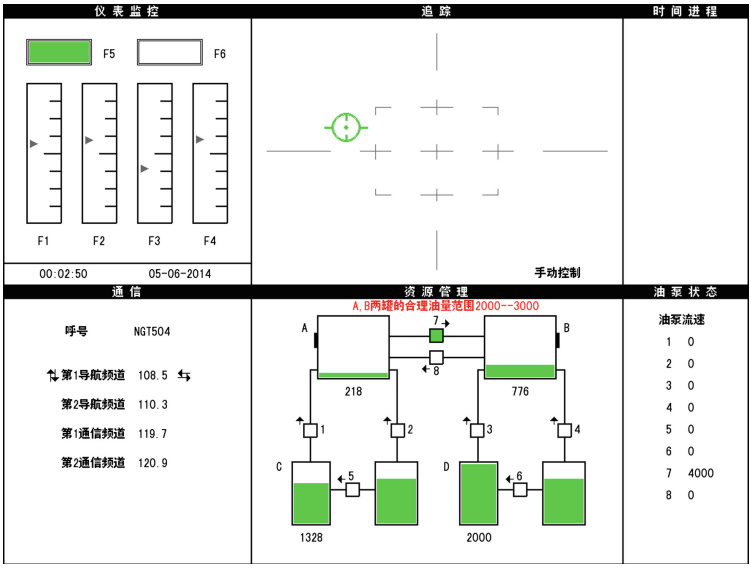

Fig. 1. Illustration of the interface in the Multi-Attribute Task Battery (MATB)

Monitoring Dashboard. Participants are required to monitor any abnormal signals on dashboard and press a key as soon as possible.

Manually Tracking a Target. Participants are required to constantly maintain the overlap between the center of green circle and the center of gray cross by using a joystick.

Verbal Communication. Participants are asked to monitor the verbal communication and adjust the frequency the communication channel as they are verbally instructed.

Resource Management. Participants were required to maintain the oil level within certain range for Tank A and B.

3 Results

One participant's AB performance is excluded from analysis based on 3 standard deviation criterion. The average T2 accuracy given correct report of T1 is listed in the Fig. 2. Attentional blink was observed in present experiment. The lowest T2/T1 accuracy is present at lag 3 (240 ms).

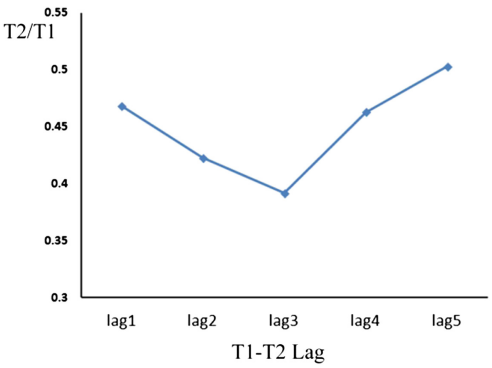

Fig. 2. The average T2 accuracy given correct report of T1 as a function of T1-T2 lags

Table 1 also listed there AB indices. (1) AB magnitude is the overall switch cost, which is the difference between the highest and lowest accuracy of T2 given correct report of T1 (T2/T1) across five T1-T2 intervals. (2) average T2/T1 accuracy measure the general cost of attentional switch. (3) AB dwell time is the temporal cost of processing T1, which is estimated by the interval when the accuracy of T2/T1 reach the lowest level.

Table 1. The AB magnitude, average accuracy of T2/T1 and AB dwell time

AB magnitude	Average accuracy	AB dwell time (ms)
0.31 ± 0.02	0.45 ± 0.02	236.1 ± 15.8

As Table 2 showed, (1) AB dwell time is significantly correlated with RT of monitoring dashboard; (2) average accuracy of T2 is positively correlated with the performance of three tasks' performance in the MATB including monitoring dashboard, resource management and tracking tasks. It is worth noting that performance get worse as RT of monitoring dashboard and tracking error increase. These results indicated that several AB indices might be useful for predicting the simulated aviation performance.

Table 2. The correlation between AB indices and MATB performance

	AB dwell time	AB magnitude	Average T2 accuracy
Monitoring dashboard (RT)	0.37*	0.14	−0.31*
Resource management	−0.24	0.23	0.36*
Tracking error	0.25	0.01	−0.30*

*indicate that two indices are significantly corrected.

4 Discussion

In flight, pilots are always facing multi-tasking situation. Attentional switch is naturally required by the multi-tasking situation in flight. As we expected, present study confirmed that indices of attentional switch can predict the performance of several tasks of simulated flight. For example, average T2/T1 accuracy, which measure the general cost of attentional switch, is positively correlated performance of three tasks of MATB. Therefore, we might be able to use attentional blink tasks to predict aviation performance.

Acknowledgement. This study was supported by grants from the National Natural Science Foundation of China (31470982 & 31200766), the key project of the Chinese Academy of Sciences (KJZD-EW-L04), and the scientific foundation of the Institute of Psychology, Chinese Academy of Sciences (Y4CX033008).

References

1. North, R.A., Gopher, D.: Measures of attention as predictors of flight performance. Human Factors: The Journal of the Human Factors and Ergonomics Society **18**, 1–14 (1976)
2. Hardy, D.J., Parasuraman, R.: Cognition and flight performance in older pilots. J. Exp. Psychol. Appl. **3**, 313–348 (1997)
3. Du, F., Ge, Y., Qu, W., Sun., X., Wu, J., Zhang, K., Zhang, L.: Attention, peri-personal perception, and visual displays in space. In: Human Performance in Space: Advancing Astronautics Research in China, pp. 4–5. Science/AAAS, Washington, DC (2014)
4. Wang, C., Tian, Y., Chen, S., Tian, Z., Jiang, T., Du, F.: Predicting performance in manually controlled rendezvous and docking through spatial abilities. Adv. Space Res. **53**(2), 362–369 (2014)
5. Du, F., Zhang, K., Abrams, R.A.: Hold the future, Let the past go: Attention prefers the features of future targets. Cognition **131**, 205–215 (2014)
6. Chun, M.M., Potter, M.C.: A two-stage model for multiple target detection in rapid serial visual presentation. J. Exp. Psychol. Hum. Percept. Perform. **21**, 109 (1995)
7. Raymond, J.E., Shapiro, K.L., Arnell, K.M.: Similarity determines the attentional blink. J. Exp. Psychol. Hum. Percept. Perform. **21**, 653–662 (1995)
8. Shapiro, K.L., Caldwell, J., Sorensen, R.E.: Personal names and the attentional blink: A visual "cocktail party" effect. J. Exp. Psychol. Hum. Percept. Perform. **23**, 504–514 (1997)
9. Visser, T.A.W., Bischof, W.F., Di Lollo, V.: Attentional switching in spatial and nonspatial domains: evidence from the attentional blink. Psychol. Bull. **125**, 458–469 (1999)
10. Du, F., Abrams, R.A., Zhang, K.: Spatial distribution of the attentional blink. Front. Cogn. **2**, 360 (2011)
11. Du, F., Qi, Y., Zhang, K.: Spatial distribution of attention during attentional blink is influenced by eye movements. Perception **42**, 907–931 (2013)
12. Du, F., Abrams, R.A.: Onset capture requires attention. Psychon. Bull. Rev. **16**, 537–541 (2009)
13. Du, F., Abrams, R.A.: Endogenous orienting is reduced during the attentional blink. Exp. Brain Res. **205**, 115–121 (2010)
14. Du, F., Yang, J., Yin, Y., Zhang, K., Abrams, R.A.: On the automaticity of contingent capture: disruption caused by the attentional blink. Psychon. Bull. Rev. **20**, 95–944 (2013)
15. Arnegard, R.J., Comstock, J. Jr.: Multi-Attribute Task Battery-Applications in pilot workload and strategic behavior research (1991)