Analyzing the effects of AiTR on situational awareness via virtual reality change blindness tasks

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Introduction

Aided target recognition (AiTR) has been proposed for integration into U.S. Army warfighter systems to improve speed of enemy detection. However, AiTR is inherently imperfect, leading to false identifications and missed threats. The visual salience of traditional AiTR bounding boxes may narrow attention exclusively to highlighted regions. This attentional tunneling can reduce awareness of uncued threats and the surrounding environment—in turn increasing soldier vulnerability.

Change blindness refers to the failure to detect environmental changes during distractions. This phenomenon has typically been examined in two-dimensional paradigms. However, this method lacks generalizability to real-world behavior due to the absence of complex scene structure and self-directed exploration present in immersive three-dimensional environments (Botch et al., 2023).

Scene perception is largely driven by expectations of familiar environments, known as schema. It remains unclear whether schema-consistent object swaps are more readily detected than schema-inconsistent ones (Wu, Wick, & Pomplun, 2014).

The purpose of this project is to determine how AiTR and schema consistency during a visual search task can impact the ability of a soldier to identify changes in their environment.

Materials and Methods

All virtual reality scenes were created using Unity with C# in Visual Studio. The HTC Vive VR headset with handheld controllers and two base stations for spatial tracking was used to display scenes. The study employed a 2 × 2 within-subjects design manipulating AiTR assistance (present vs. absent) and schema of object swaps (inconsistent vs consistent with environmental schema).

Each trial consisted of a shooting phase, a scene transition, a swap detection phase, and the progression to the next trial (Figures 1–4). Participants completed 20 trials across three schema environments (beach, restaurant, city) and two control environments. When present, AiTR overlays appear as red bounding boxes around enemies (Figure 1). Scenes were pre-constructed with controlled randomization: object swaps (0–5 per trial) were randomized while accounting for size and contextual plausibility. Enemy targets were also randomly generated (1–10 per trial) from fixed spawn points.

The number of correct swap detections (H) and false swap detections (FA) were recorded to calculate d', a measure of situational awareness reflecting signal–noise discrimination ($d' = z(H) - z(FA)$).

Materials and Methods (continued)

Figure 1 (left): An example of the shooting phase in the beach scene in the AiTR On condition. Participants must locate enemy targets as quickly as possible with a one-minute time limit.

Figure 2 (right): Participants turn 180° and press the "Swap Phase" button to initiate the next phase. This action triggers object swap while the scene is out of view.

Figure 3 (left): The scene reloaded with schema-inconsistent object swaps (highlighted in green). In this trial, a beach chair is replaced with a restaurant booth and a sandcastle with a fire hydrant. Participants must select changed objects.

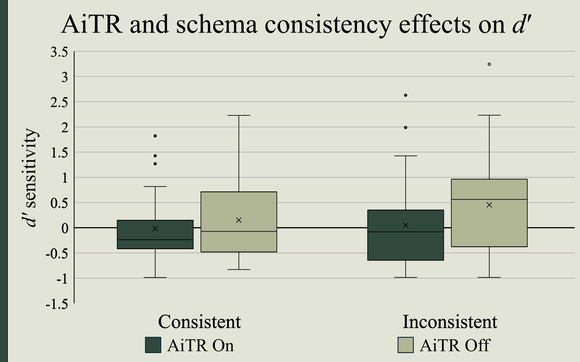
Figure 4 (right): Participants press the "Teleport" button to proceed to the next trial, returning to the shooting phase in a new, randomized environment that may include AiTR.

Results

Effects of AiTR and Schema on d'		
Effect	Coefficient	p-value
AiTR (Off)	0.1441	.099
Schema (Consistent)	−0.0915	.010
AiTR (Off) × Schema (Consistent)	−0.0602	.277

Table 1 (above): A General Linear Model examining the effects of AiTR and schema consistency on d' revealed a significant main effect of AiTR, $F(1, 216) = 6.79$, $p = .010$. The main effect of schema, $F(1, 216) = 2.74$, $p = .099$, and the interaction, $F(1, 216) = 1.19$, $p = .277$, were not significant. $R^2 = 0.047$ (adjusted $R^2 = 0.034$).

Results (continued)



Graph 1 (left): Mean detection sensitivity (d') across schema consistency and AiTR presence. Schema-inconsistent scenes show higher sensitivity across conditions, with swap detection performance highest when AiTR is off.

Data from $N = 11$ participants (20 trials each) were analyzed using a General Linear Model to compare the effect of AiTR presence with schema consistency on d' (Table 1). A paired t-test showed participants spent significantly less time searching for targets with AiTR ($M = 11.2$, $SD = 4.3$) than without ($M = 33.1$, $SD = 12.7$), $t(10) = 7.91$, $p < .001$.

Conclusion

Results show that schema-consistent swaps significantly decreased change detection sensitivity (d'), while the AiTR condition and the AiTR-schema interaction were not statistically significant, indicating that schema effects remained consistent across conditions. In a combat context, this suggests that soldiers more readily detect changes that violate expectations, regardless of AI assistance. AiTR reduced shooting time and was associated with descriptively lower d', suggesting a possible attentional tunneling trend.

However, this may also reflect reduced shooting time under AiTR, which could limit scene encoding. Additionally, low d' values in both AiTR On conditions indicate a potential floor effect. Future studies should consider decreasing visual search difficulty and standardizing exposure time to isolate the effects of AiTR on situational awareness.

References

Botch, T. L., Garcia, B. D., Choi, Y. B., Feffer, N., & Robertson, C. E. (2023). Active visual search in naturalistic environments reflects individual differences in classic visual search performance. *Scientific Reports*, *13*, 631. https://doi.org/10.1038/s41598-023-27896-7

Wu, C.-C., Wick, F. A., & Pomplun, M. (2014). Guidance of visual attention by semantic information in real-world scenes. *Frontiers in Psychology*, *5*, 54. https://doi.org/10.3389/fpsyg.2014.00054