

Human Performance Testing for Cognitive Science-Informed Information Provision for International Nuclear Safeguards Inspectors

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ABSTRACT

- More potentially safeguards-relevant information is available to inspectors and analysts than ever before. However the mere provision of more information is not necessarily useful and can result in confusion, errors, frustration, or other symptoms of information overload.
- We use cognitive science principals including human performance testing to experiment with the mechanisms to provide visual information to inspectors to make them more timely, accurate, and situationally aware in completing their in-field activities.
- Our results indicate that different visualizations do have an impact on the timeliness of task completion. There are minor and unexpected impacts on accuracy, and situational awareness stays approximately the same based on individual differences.

BACKGROUND

- We conducted a detailed task analysis to assess what tasks inspectors complete in the field during safeguards verification activities, and the information available to them.
- We cross-referenced the task analysis with a detailed cognitive science literature review to identify common themes and prioritize areas of research that would have high impact for both the safeguards and cognitive science communities. The three prioritized research areas included: visual inspection, wayfinding, and knowledge transfer.
- We designed a series of human performance experiments to assess how different provision or information to an inspector would impact her accuracy, timeliness, and situational awareness during in-field verification activities.
- We describe each experimental area in more detail and, when available, results and recommendations.

VISUAL INSPECTION

METHODS

Participants were asked to compare two side-by-side electronic lists – an “inspector list” on the left, and a “facility list” on the right. The inspector list was presented six different ways, with each permutation of three order-based schemes and two color-based schemes. Participants were asked to compare their inspector list to the facility list, and to identify changes of the background screen color behind the lists. The facility list contained multiple variations from the inspector list such as partially correct items, missing items, and transposed items. Figure 1 shows two of the six list presentations, and two of the background colors used in the situational awareness task.

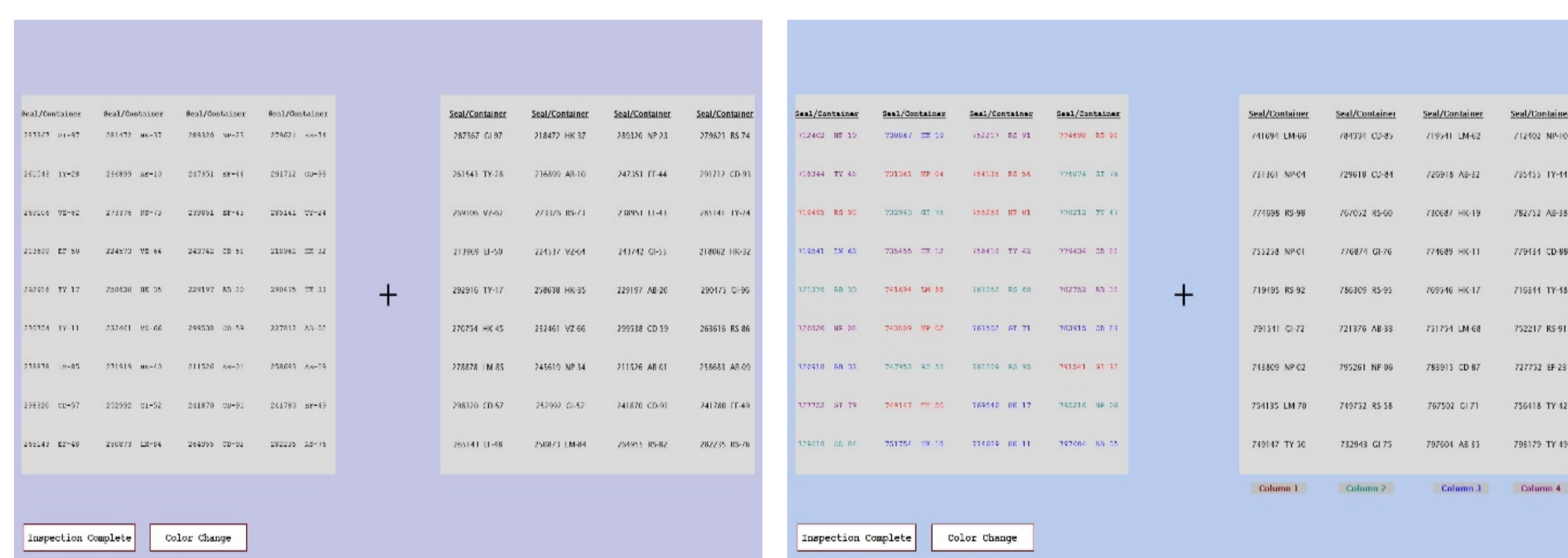


Figure 1 – Two list presentations and background colors.

RESULTS

We saw significant improvements in reaction times for lists presented with color-coding according to column, and facility order. While most participants did not modify their search strategy to take advantage of the numerical order condition, those who did had faster reaction times as well. Accuracy remained approximately the same across conditions, except in the fastest condition (in which the two lists were in the same order), in which there was a decrease in accuracy for transposed items which are an important yet subtle change. There was not a significant difference in the ability to detect color-change between conditions, which was attributed to individual differences.

DISCUSSION

This experiment compared two complete lists, and indicated that the presentation of the inspector list can have high impacts on the timeliness of task completion. Current experiments address partial-to-full lists as one might find in a random sampling for an interim inspection, and list-to-item comparisons including a variant with an interactive task-tracking capability.

WAYFINDING

METHODS

Participants were given a guided tour through an complex former nuclear facility, during which time eight facility landmarks were indicated. Participants received one of three map conditions: study but not carry a map, study and carry a map, or have no map at all. Following the tour, participants completed a battery of tests measuring their knowledge of the route, landmarks, and overall facility awareness, including: pointing to the indicated landmarks; finding shortcuts between landmarks; drawing their route and landmark locations on a map; recognizing landmarks and other the items seen in the facility from a series of photos; and a self-assessment of their sense of direction.

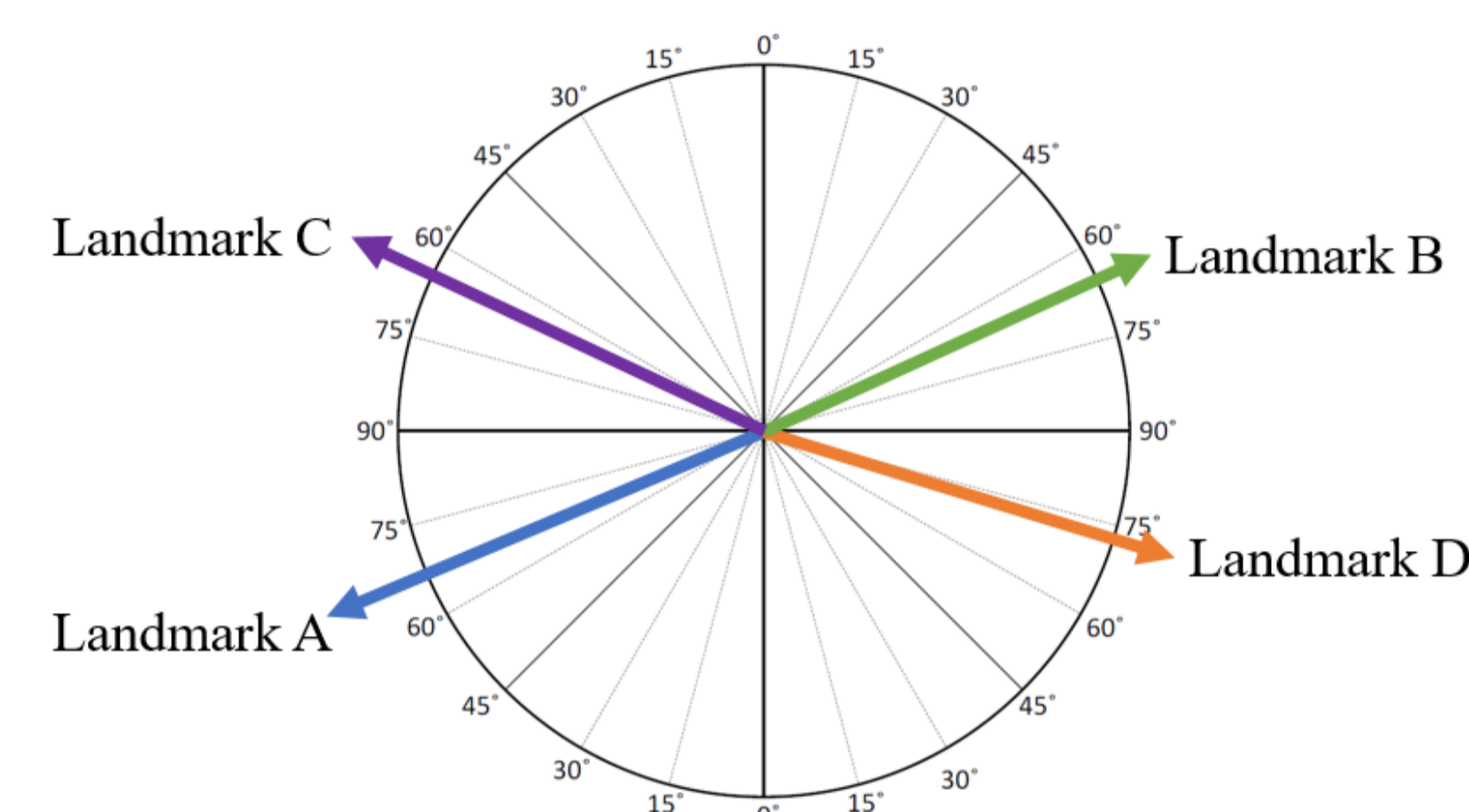


Figure 2 – Example pointing task results.

RESULTS

Participants who had access to a map (either to study or study and carry) performed better at a task in which they pointed to the landmarks indicated on the tour. Participants who did not carry a map performed better than those who had a map with them on a landmark recognition test that assessed their knowledge of items that were on their tour route but not pointed out, compared to items that were not on their route. Self-assessed sense of direction had a significant effect on the pointing task, landmark recognition, and a task to draw the route and landmark locations on a blank map.

DISCUSSION

The findings of this experiment suggests that receiving a map before receiving a guided tour can improve a participant's knowledge of the facility, perhaps at the detriment of their situational awareness on the route. We are developing additional experiments to modify the map presentations including a highly detailed CAD drawing and two different 3D map representations.

KNOWLEDGE TRANSFER

METHODS

Participants will be asked to view a series of abstract images and record their observations in each of four note-taking conditions (no notes, pencil and paper only, digital camera, or pencil/paper with a digital camera). After a waiting period of several days, the participants will re-view the images with some modification, and will be asked to identify the specific changes. Future experiments in this area might include providing the participant notes from the first trial to new participants to identify changes.



Figure 3 – Example abstract image, courtesy of IARPA MICrONS project.

CONCLUSION

- The provision of information has been demonstrated to improve performance on inspection-like activities performed in the laboratory setting.
- Further work is needed to experiment with expert participants who more closely resemble highly trained safeguards inspectors.
- Future work could include testing by-request scenarios from safeguards inspectorates, analyst-relevant information provision experiments, 3D or virtual information presentation environments, and training mechanisms.

ACKNOWLEDGEMENTS

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