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

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.

- 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 asses 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 I shows two of the six list presentations, and two of the background colors used in the situational awareness task.



RESULTS

Figure 2 – Example pointing task 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

Seal/Container	Seal/Container	Seal/Container	Scal/Container		Seal/Container	Seal/Container	Seal/Container	Seal/Container	Seal/Container	Seal/Container	Seal/Container	Seal/Container		Seal/Container	Seal/Container	Seal/Container	Seal/Container
261048 11-97	281472 нк-37 286899 ам-10	289320 wr-23 267351 sr-44	274621 xx-14 291712 cu-93		287367 GL97 261543 TY-28	218472 HK 37 216800 AB-10	280320 NP 23	279621 BS 74	102402 NF 15	VU0DAV IIR 10 VU1DA1 NP 04	(5221) BS 91	994690 RS 00		741694 LM-66	784334 CD-85	719541 LM-62 726918 A8-42	712402 NP-10
260106 V2-62	273376 85-73	239851 EF-45	285141 77-24		529106 VZ-62	273378 IB-73	238951 (1-4)	285141 19-24	100495 RS 92	702940 67 75	755250 NV 01	990212 7 8 47		774098 RS-98	767052 RS-60	730687 HK-19	762752 AB-38
213600 EF-50	224573 VS 64	243742 CD-51	210062 337-32		213969 EF-50	224537 VZ-64	243742 GI-55	218062 HK-32	11.9543 EM 62	735455 IIX 12	758410 TV 42	228404 CD CC		755258 NP-01	776874 GI-76	774689 HK-11	779134 CD-88
202010 TV 17	250600 BK 05	229197 AD 30	290475 IIK 33	+	292916 TY-17	258638 HK-35	229197 AE-20	290173 GI-96	121374 AD 30	741694 TM 88	767057 RS 60	702752 AD 31	+	719495 RS-92	786309 RS-95	769546 HK-17	716344 TY-18
210104 99-11	232461 VS-66	299530 CD-59	227012 83-07		270754 HK 45	232461 VZ 66	299538 CD 59	263616 RS 86	120020 NF DD	740009 NP 02	767507 67 71	202815 OD 11		791341 CI-72	721376 AB-33	751754 LM-68	752217 RS-91
278878 IM-85	271919 нк-40	211526 AH-01	258683 As-09		278878 I M 85	245610 NP 34	211526 AB 01	258683 AB 09	120510 60 32	747952 RD 50	765309 RS 95	781541 at 12		718809 NP 02	795261 NF-06	788913 CD-87	727752 BF-28
298820 CD-57	252992 01-52	241870 CD-91	241780 sr-49		298320 CD-57	252002 GI-52	241870 CD-91	241780 FF-49	1,775,2 AT 79	749147 SY 50	769542 88 17	795216 NP 06		754135 LM 70	749752 RS 58	767502 CI 71	755418 TY 42
265143 E2-48	290873 LN-84	200955 CD-52	282235 3.5-75		265143 (1-48	250873 LM-84	254955 RS-82	282235 IIS-76	139010 AD D4	751754 18 10	TTERTS - BE-11	757004 60-35		749147 TY 50	732943 GI 75	797604 A8 83	798179 TY 49
														Column 1	Column 2	Column 3	Column 4
Inspection Complete Color Change								Inspection	Complete Co	olor Change							

Figure I - 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.

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.

KNOWLEDGETRANSFER

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.

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.

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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.

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