



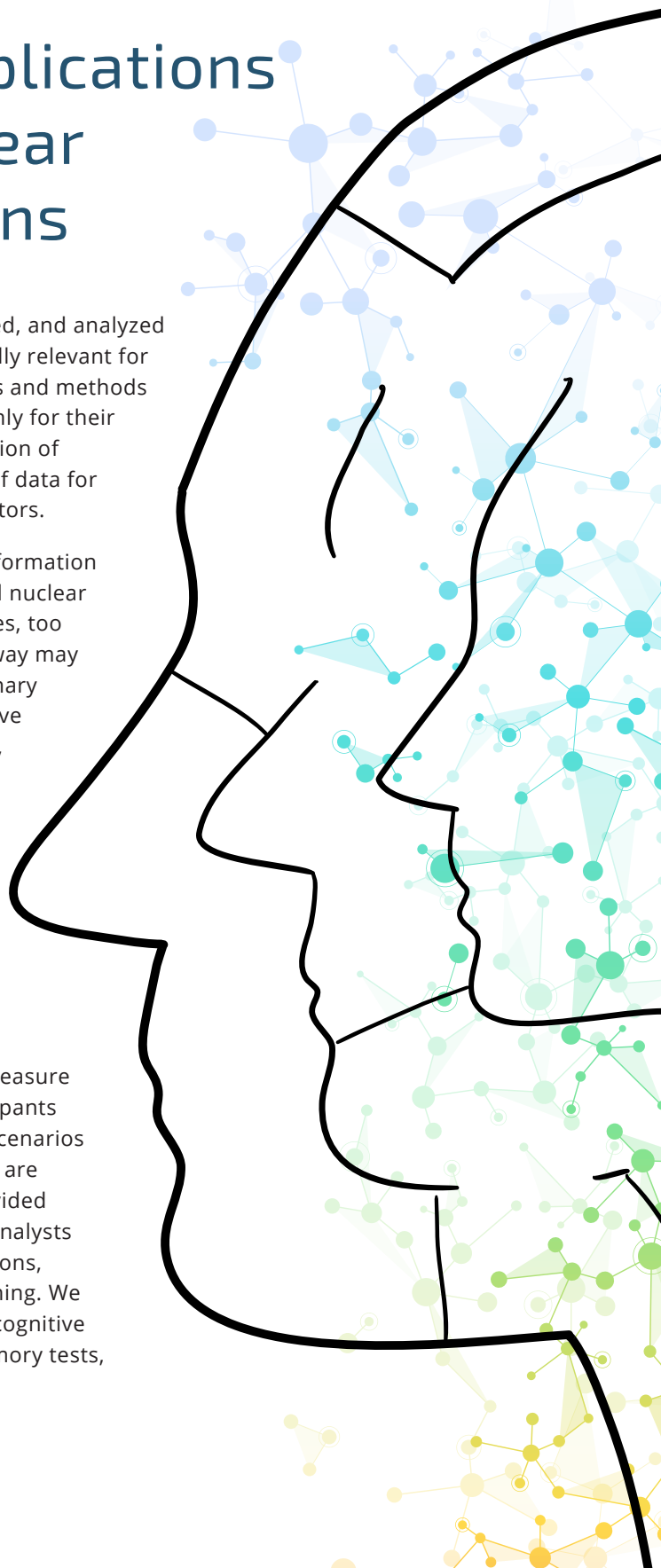
Cognitive Science Applications to International Nuclear Safeguards Inspections

In today's Information Age, more data is being created, shared, and analyzed than any other time in history. Some of that data is potentially relevant for international nuclear safeguards – the collection of measures and methods used to verify that states are using their nuclear programs only for their declared, peaceful purpose – but providing even a small portion of this emerging information could result in massive amounts of data for International Atomic Energy Agency (IAEA) safeguards inspectors.

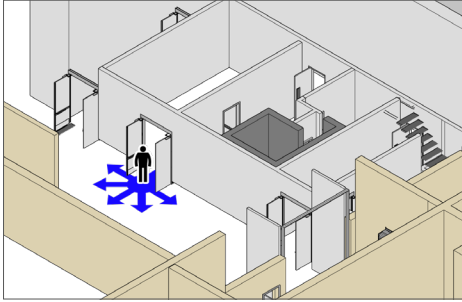
Cognitive science research shows that excessive access to information can be confusing, frustrating, or distracting. For international nuclear safeguards inspectors conducting in-field verification activities, too much information, or information presented in a confusing way may lead to inspection errors or omissions. Sandia's multidisciplinary team of experts is applying fundamental principles of cognitive neuroscience to the field of international nuclear safeguards, specifically by evaluating the type and quantity of safeguards information used by inspectors and how to most effectively convey that information. By conducting human performance tests using safeguards-like activities, Sandia can make recommendations that could improve the accuracy, timeliness, and situational awareness of safeguards inspectors working in the field.

What We Do

We design and execute novel human performance tests to measure the accuracy, timeliness, and situational awareness of participants in experiments that simulate in-field safeguards inspection scenarios and headquarters-based analysis activities. Our experiments are intended to determine the impact of how information is provided to, or recorded by, international safeguards inspectors and analysts so we can make recommendations on information visualizations, information provision mechanisms, record keeping, and training. We incorporate assessment techniques from across the field of cognitive science, including eye tracking, behavioral observations, memory tests, situational awareness, and self-assessments.



Recent Experimental Research



Wayfinding is a form of spatial cognition in which people determine where they are in an environment and how to navigate to where they want to go. Wayfinding can include navigation by map, landmarks, or verbal/written directions outdoors or indoors. When safeguards inspectors are escorted from one part of a nuclear facility to another, they must rely on maps and their wayfinding abilities to recall important equipment and where it was located, determine if they have been led to the correct location, and identify if the route taken was circuitous. We are studying the impact of map visualization and individual differences for safeguards-relevant wayfinding tasks.

Knowledge Transfer refers to sharing information and experience across different teams or parts of an organization. When one team hands off work to another, or when people move in or out of an organization, transferring knowledge is crucially important for maintaining continuity. Knowledge transfer is a critical component of international safeguards inspection activities. Facility expertise must be passed from experienced to newer inspectors and information obtained from in-field inspection activities must be passed from one inspector (or inspection team) to another over extended time periods as well as to IAEA Headquarters. The time frame of knowledge transfer for IAEA activities is much longer than for domains that have been studied in the past, such as shift changes for medical workers, making effective knowledge transfer more challenging. We are studying how modalities of note-taking impact recognition of changes in safeguards-relevant visual environments.

Visual Search refers to how the human eyes scan a visual environment to find an intended target. Visual search is prominent in many safeguards tasks, such as those in which an inspector compares a list (e.g., inventory list, change report, or sampling plan) to their environment. In some cases, the structure of lists available to IAEA inspectors may be altered to align with the inspector's specific task and knowledge about material or item locations within a nuclear facility. Using computer-based simulations and eye tracking, we are studying where and how users are interacting with list information, and how the visual presentation of lists impacted user performance.

Serial/Container	Serial/Container	Serial/Container	Serial/Container	Serial/Container	Serial/Container	Serial/Container	Serial/Container
430024 TD-04	431032 AD-53	430788 LP-09	430482 NP-05	430804 CD-27	430865 NP-07	430888 NP-45	430891 AD-27
430905 NP-07	430708 EP-24	430572 LP-09	430432 NP-08	430509 LP-06	430210 AD-28	430891 EP-04	430514 EP-03
430905 LP-06	430501 NP-41	430788 NP-09	430502 NP-05	430509 AD-30	430886 EP-03	430788 LP-09	430521 NP-01
430788 NP-01	430409 AD-30	430432 EP-03	430502 LP-05	430808 CD-09	430432 NP-06	430788 CD-09	430521 NP-02
430905 NP-05	430504 LP-05	430788 NP-07	430702 NP-02	430404 NP-05	430719 NP-05	430512 TP-09	430514 TP-06
430708 NP-05	430219 TP-01	430509 LP-06	430502 LP-07	430502 LP-05	430210 LP-05	430888 AD-21	430512 NP-03
430905 NP-03	430509 NP-04	430509 LP-06	430719 NP-05	430771 NP-41	430512 CD-08	430511 NP-09	430521 NP-01
430905 NP-01	430771 NP-04	430512 NP-05	430702 NP-06	430749 NP-05	430432 EP-03	430512 CD-02	430519 TP-04
430708 NP-04	430512 NP-05	430512 NP-05	430504 NP-01	430805 NP-06	430512 CD-06	430512 CD-05	430788 NP-06

Columns 1 Columns 2 Columns 3 Columns 4

Inspection Complete Color Change

Example screen from an eyetracking test in which we test how participants' performance on a list-matching activity changes with different presentations of the list.

Machine Learning models are being evaluated for adoption across multiple visual safeguards verification tasks such as satellite imagery analysis and surveillance camera data review. But all models – just like all humans – can occasionally be wrong. We are studying the impacts of incorrect responses from simulated machine learning models on human performance in domain-general and safeguards-relevant visual identification tasks, including the frequency and type of errors from models, and the visual representation of model results.

The Team

Our research is a collaborative effort between subject matter experts on international nuclear safeguards and inspections and cognitive research scientists with expertise in experimental design, data science, and human visual perception and comprehension. This unique cooperation allows us to develop scientifically based recommendations on training and information provision for international nuclear safeguards inspectors, and add significant new work to the cognitive science corpus encompassing information visualization, cognitive load, and memory.

For more
information,
please contact

Zoe Gastelum
International Safeguards & Engagements
zgastel@sandia.gov, 505.401.6959



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND2023-03277M

