



JDiBrief – Security

Visual Inspection with X-rays: SUMMARY (1 of 5)

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The success of recent terrorist attacks has disclosed to the public the dangers connected with failure in detecting threats and prohibited items at checkpoints.

Visual inspection with X-rays is currently one of the most cost-effective security measures at major transportation checkpoints for goods and vehicles. More often than not, performance of X-ray-aided screening systems ultimately depends on the human operator. The study of how inter-observer variability and human factors affect the use of X-ray imaging is thus crucial. The development of routine methods to measure the potential performance of human screeners is likely to aid the correct selection of security staff and to improve the efficacy of visual inspection in aviation and non-aviation security settings. Selection and training of security personnel for the London 2012 Games has also recently highlighted this requirement. To this objective, neuropsychology and visual cognitive neuroscience offer an invaluable source of research evidence and testing protocols that can either be directly employed or modified, and more finely attuned for security applications.

X-RAY IMAGE INTERPRETATION: X-ray image interpretation poses peculiar challenges to the human screener, with its cluster of superimposed shapes that are often seen from unusual viewpoints. In a professional environment, continued training with the screening task plays a fundamental role in building and maintaining a mental library of images of threats and prohibited items, and in optimising efficiency of the screening and decision-making process. However, specialised training is not as effective when it comes to the intrinsic visual complexity of the image, causing well-known shapes and objects to go unrecognised.

TRANSLATIONAL RESEARCH: Based on the type of visual challenge posed by transmission X-ray images and the similar challenge that is typical of a well-known experimental testing instrument, it is possible to draw a parallel between the security domain and the visual cognitive neuroscience domain. We can use the knowledge of this similarity to predict what type of individual differences may be relevant and what personnel selection instruments may help improve efficiency of the screening system.

In the Embedded Figures Test (EFT - from cognitive neuroscience) a target shape is to be found in a complex shape. When it is inserted in the complex shape, the target shape changes its visual meaning (for example, it appears as part of a different shape and loses its apparent individuality). In order to be identified, it has to be 'disembedded' from its confounding context. People with superior disembedding ability could therefore be expected to outperform more context-dependent people also in the security X-ray screening task. In the general population there is a quick way to know whether a person may be good or not at disembedding, by means of a self-report testing instrument, the Autism Quotient questionnaire, which contains an 'attention to detail' subscale.

Our research suggests that the use of the 'attention to detail' subscale may help identify, within a group of prospective screeners, individuals who are less likely to miss threats when present at no cost of task speed. The author is engaged in further research to test and develop an ad-hoc testing instrument.



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Visual Inspection with X-rays: TOPIC OVERVIEW (2 of 5)

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Several billion pieces of baggage pass through a single international airport every year, and legal borders of a typical Western country are crossed by thousands of people, vehicles, animals, plants and goods every day. Ensuring that the movement of these items is done in a safe manner is a critical component of security policy.

DEFINITION: One of the most commonly adopted security measures at checkpoints is visual object inspection of the content of luggage and vehicles through two-dimensional X-ray images. In most cases, human screeners are employed to inspect the images and initiate more thorough security checks (e.g. hand searches) whenever suspicious content is detected at the point of visual inspection. Virtually all items taken onboard air transport pass through this process. A smaller percentage of the goods transported by land and/or maritime transport go through similar security checks. Other checkpoints such as entry points for public events, high-security facilities, mail distribution centres, explosive detection and disposal sites, use X-ray equipment for security reasons.

THREATS: The security risks connected with mass transport were amplified on an international stage by the successive terrorist attacks in New York (2001), Madrid (2004) and London (2005). Consequently, political and public awareness about the potentially devastating consequences of threat detection failure at security checks has never been more acute. New regulatory initiatives and requirements have emerged in the new millennium, including an extension of the scope and range of routine visual inspections (e.g. with the introduction of body scanners at airports, more restrictions on carry-on luggage, and a more extensive use of X-ray screening at entry points).

The number of prohibited items that pass through security checkpoints undetected is not easily assessed and quantified. However, results of laboratory research with computer-generated images and regular on-site tests and training sessions (even with experienced personnel at airports) have highlighted the intrinsic difficulty of visual inspection for the human screener. Since automatic detection algorithms do not currently appear to be a viable alternative to human screeners, it seems important to devise ways to optimise 1) the quality of the images produced (i.e. via technology) without compromising throughput rates, and 2) the efficacy of the visual inspection process (i.e. via human factors and personnel selection). This Brief will focus on the latter point.

RESEARCH OBJECTIVES: The interpretation of X-ray images and the decision-making that follows involves a range of psychological factors. Screeners' performance is thought to be the product of both individual-specific and contextual components, such as pre-existing aptitudes and abilities, visual expertise, training, motivation and attention, and knowledge of the correct action to undertake. Certain image characteristics pose difficulties to recognition skills (see Analysis brief), and these are not easily overcome even with training. Given this, it seems sensible to develop tools for personnel recruitment that improve the selection of those individuals with greater baseline aptitude for X-ray screening.



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Visual Inspection with X-rays: ANALYSIS (3 of 5)

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TRANSMISSION X-RAYS: In X-ray transmission, matter particles (X-ray photons) are projected with a suitable energy through the items to be inspected and picked up by a detector at the opposite side. The resulting X-ray image is the distribution of those particles that have passed through the item and are recorded by the detector. Depending on content density of the item being screened, X-rays are subjected to different levels of attenuation, which are visually translated into different levels of grey and/or different colours. The final image is a two-dimensional projection of the density (i.e. attenuating properties) of all the three-dimensional objects placed along the paths of the X-rays. Transmission X-ray images comprise a cluster of shapes that may be represented from an unusual point of view, depending on their orientation inside the item to be scanned in relation with the X-ray source and detector. Shapes corresponding to objects that are present on different planes but along the same path in the scanned item will appear superimposed. Human screeners face the difficulty of interpreting complex images, and pattern recognition software does not seem to represent a valid substitute of the human visual system.

COMPONENTS OF HUMAN SCREENERS' PERFORMANCE: Actual figures on overall system accuracy and reliability (including the human component) and specific figures on screeners' performance are generally treated as classified information and never disclosed to the public. Academic research publications on studies with professional screeners tend to report normalised rather than absolute performance values (i.e. performance is expressed in relative terms, with reference to an arbitrary baseline). In-depth studies on human factors and the effect of experience are available, with an emphasis on aviation security screening. They focus on baggage screening and concern interventions to monitor pre- and post-training X-ray screening performance, to provide training and feedback. Specialized tasks that aim to test visual abilities in the context of X-ray images have been also used. These studies have collectively found that the interpretation of X-ray images and decision-making involves a range of psychological factors, among which pre-existing aptitudes. Based on research done in a different scientific tradition (i.e. neuropsychology and visual cognitive neuroscience), there is good reason to believe that an individual's ability to interpret X-ray images by identifying their component items may partly rest on a baseline set of skills that confers 'field independence' and can be measured before training.

HYPOTHESIS – With our research project we aimed to ascertain whether individual traits predicted differences in the ability to identify threats with actual security X-ray images. We suggest that threat detection in security X-ray images share challenges equivalent to those entailed by neuropsychological tasks such as the Embedded Figures Test (EFT; see the 'New knowledge' brief) where spontaneous attention to detail plays a key role. As such, one would expect that individuals with higher attention to detail should also have superior X-ray screening aptitude. We further hypothesise that it is possible to identify individuals who will perform better at security X-ray screening by administering a self-report instrument focused on autism spectrum traits.



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Visual Inspection with X-rays: NEW KNOWLEDGE AND APPLICATIONS (4 of 5)

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COMPARABLE CHALLENGES: A parallel can be drawn between a typical security screening task and a well-known neuropsychological test – the Embedded Figures Test (EFT). Like a screening task, the EFT requires object localisation and recognition within a cluster of confounding shapes (see Figure 1).

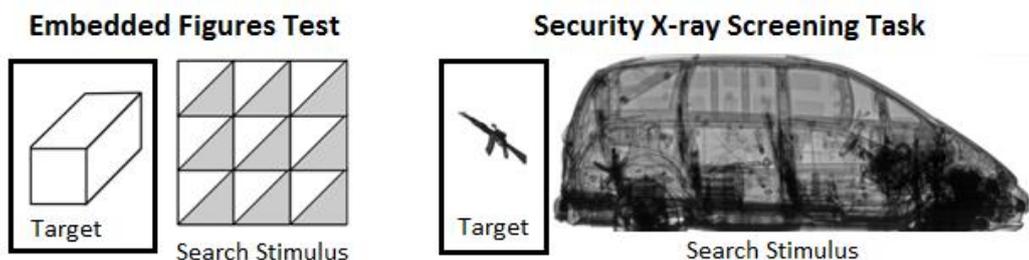


Figure 1 – the comparable challenges presented by the EFT and the X-ray screening test

Fact 1: Individuals with a diagnosis of autism spectrum disorder (ASD) outperform non-autistic individuals in the EFT. Their enhanced abilities are attributed to heightened attention to visual detail and sensitivity to trivial changes in the visual environment.

Fact 2: ASD traits are present in the non-clinical population and individuals can be localised on a continuum from normality to clinical relevance for each trait. A psychometrically validated self-report questionnaire (AQ) is available to measure where any given individual lies on the continuum of ASD traits.

PREDICTION: Scores on the ‘attention to detail’ subscale of AQ could be used to predict individual differences in performance on a security X-ray screening task.

HYPOTHESIS TESTING: Two groups of participants were randomly selected from the lower and the upper tail of the distribution of attention to detail scores in a sample of the general population (see Figure 2). None of them had worked in the security sector. A series of small-vehicle security X-ray images were displayed in a laboratory simulation of the screening task, where participants had to decide whether at least one of five target threats (Glock, Colt, Kalashnikov, bowie knife, pipe bomb) was present. As predicted, the group with higher attention to detail were found to have a significantly higher *hit minus false alarms rate* (but they were not slower at responding) than the group with lower attention to detail.

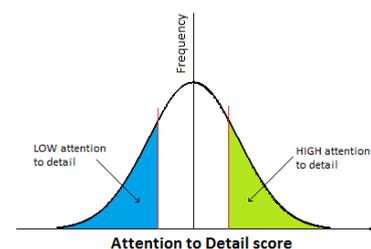


Figure 2 – schematic of the participant-to-group assignment logic based on the distribution of attention to detail scores in a population sample

CONCLUSION: Although further research is needed, an individual differences approach looks very promising in this field. Experimental testing instruments can be borrowed by neuropsychology and directly applied, to improve the process of visual inspection. The author is currently engaged in research concerning the psychometric validation of an ad-hoc personnel selection instrument.



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Visual Inspection with X-rays: RESOURCES (5 of 5)

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