Designing out terrorism: human factors issues in airport baggage inspection

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Abstract

All air passenger baggage is screened at airports by means of 2-D X-ray imaging which results in a computer display of each luggage item that is then visually searched by an operator (screener) for the presence of potential threat items (e.g. knifes, guns, improvised explosive devices [IED]). Despite improvements in screener training and available technology (e.g. image enhancement functions, threat image projection, 3-D X-ray imaging) the performance of screeners is variable which leads to the potential for terrorist threat to aircraft and passengers. A new training scheme to improve performance in baggage screening is under development (EPAULETS: Enhanced Perceptual Anti-terrorism Universal Luggage Examination Training System) and some of the initial human factors issues that underlie variable screener performance are considered.

Imaging interpretation

The detection and recognition of potential threat items within cabin baggage involves a human operator inspecting and interpreting a two-dimensional (static or dynamic) X-ray image of hand luggage or clothing item. Consequently this process is similar to the task of medical image interpretation, where a radiologist inspects an image (generally two-dimensional but can be three-dimensional) of human anatomy, which may be static (e.g. chest radiograph) or dynamic (e.g. ultrasound scans). Therefore the medical image inspection task is very similar to aircraft baggage inspection and data and theoretical approaches found applicable in the former, which has a larger research base, should be able to be applied to the latter. More strictly, baggage inspection relates to a typical radiological screening situation where many normal images are inspected which leads to the detection of relatively low numbers of abnormalities. For instance, in breast screening in the UK, circa 1.5 million women are screened each year, which leads to the detection of some 10,000 cancers.

Ergonomic differences between the two imaging interpretation situations mainly concern the viewing conditions themselves. In medical imaging the image is viewed in a quiet and darkened room with no extraneous distractors, whereas in airports the image is viewed in normal room lighting with many potential distractors present. There are specific reasons for this arrangement which are not considered here.

In both imaging domains, even when individuals are working to the best of their abilities, errors can still occur primarily due to the very large range of appearances of potential targets. Errors can be false positives or false negatives. False positive detections in baggage inspection are dealt with by subsequent manual examination of the bag and can cause delay to the passenger as well as adding to the workload of security personnel. False negative decisions are very problematic as a potential threat item is then allowed to be carried on to the aeroplane. Consequently it is these errors which primarily need to be addressed.

Modelling image inspection

A theoretical model has been developed to adequately describe and account for these errors in medical imaging (c.f. Gale, 1997). The model can also be applied to baggage inspection (Gale et al., 2000). This model emphasises the various stages of the visual inspection process. These are that the individual first approaches any new image with a potential hypothesis (schema) about its nature (i.e. normal, abnormal etc.).

An initial glance at the image yields a rapid global processing which leads on to serial detailed visual inspection of the image. This serial process entails the dynamic process of bringing particular image areas on to the fovea (or specifically an area of visual attention somewhat larger than the fovea – termed the Useful Field Of View, UFOV) for detailed inspection. The eye moves over the image in a series of very rapid saccadic eye movements coupled with intervening fixations. Vision is largely inhibited during an eye movement and so the perception of the image can be conceived of as a series of glances of varying fixation times interleaved with ballistic saccadic eye movements. Precisely where the eye fixates and then moves to fixate next is considered to be as a result both of the cognitive plan for looking coupled with the information gleaned from each glance.

The search process can be monitored by suitably recording the screener's eye movements. This allows false negative errors to be characterized as due to the process of search, detection or interpretation. Search errors are where the observer has clearly failed to look directly at, or near to, the potential threat area. Consequently the threat was not encompassed within focal vision. Detection errors are where the observer has actually looked at, or near to, the potential threat but has failed to detect the abnormal features. Typically research has demonstrated that detection errors are accompanied by eye fixations at, or near to, the abnormality of less than one second. Similar in nature to detection errors are interpretation errors where the observer has clearly looked at or near to the abnormality but for more than one second, yet has still failed to interpret the information there appropriately. It is taken that the observer has actually had time to detect the appropriate visual information but has then failed to interpret this information adequately (i.e. an error of cognition).

In general most errors in imaging interpretation are found to be due to detection or interpretative processes rather than search per se. - although visual search is a necessary part of the overall inspection process. Therefore, recording visual search of these images appropriately is key to determining whether errors are due to visual or cognitive factors which can be elicited on the basis of fixation time measures. The EPAULETS project utilises eye movement recording in experimental designs employing MRMC (multiple reader multiple condition) ROC analyses to quantitatively assess error performance.

Discussion

Previous work (Gale et al., 2000) studied performance in an IED identification task and demonstrated that more interpretation errors were found with baggage screening than have typically been found in medical imaging interpretation. This was surprising and may well indicate that examining baggage items for potential IEDs is a very difficult cognitive task. However, an alternative explanation may be that the particular IEDs used in this study were very difficult or of low visual conspicuity.

Building on this research the EPAULETS project will develop an image database of air passenger baggage items, some of which contain potential threat items. By presenting these to screeners and monitoring their visual search behaviour then their skills, together with the precise nature of false negative errors will be detailed. Information from numerous empirical studies will then be used to inform advanced training strategies with the overall aim of minimising the possibility for baggage screeners to make errors.

References

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