Determinants of Airport Security
X-ray Screeners’ Detection Performance

By Prof. Dr. Adrian Schwaninger

X-ray screening of passenger bags is an essential component of airport security. X-ray screeners have to decide within seconds whether an X-ray image of a passenger bag is harmless or whether it might contain a prohibited item and has, therefore, to be sent to secondary search. Several factors influence detection performance of X-ray screeners. Figure 1 shows a slightly adapted version of a model published ten years ago \[^1\]. On the left, determinants of detection performance are depicted: selection tests, computer-based training (CBT), threat image projection (TIP) and practical tests. Supervision and quality control are important to ensure that these processes and tools are implemented in a way that enables screeners to achieve and maintain good detection performance results. I have pleasure in reviewing the different aspects of this model from a scientific and practical point of view and adding my opinions on where we stand in Europe regarding the quality of implementation of these processes and tools.

**Selection Tests are Important but Often Underestimated**

X-ray screening is a demanding task in which prohibited items have to be detected even if they are depicted from an unusual viewpoint, superimposed by other objects or placed in cluttered bags (Figure 2). Research has shown that there are large differences between people regarding visual-cognitive abilities and aptitudes needed in X-ray screening are employed as screeners \[^5-4\]. Supervision and quality control on this matter varies substantially across different European countries. In some of them, a scientifically validated object recognition test is mandatory in addition to other requirements for pre-employment assessment. In many other countries, this is not the case and requirements for employment as a screener are much lower, which provides a first explanation for the variation in detection performance across European airports.

**Computer-based Training is Essential but Not Always Effective**

In order to learn which items are prohibited, what they look like in X-ray images, and to keep up to date with new and emerging threats, computer-based training (CBT) can be a very effective and efficient tool \[^5, 6, 7\]. However, not every CBT is effective. For example, in a study conducted by Koller, Hardmeier, Michel, and Schwaninger \[^8\], training with an individually adaptive CBT containing a large library of prohibited items (X-Ray Tutor, XRT) was compared to two other CBT systems that were not adaptive and had smaller image libraries. Detection performance was measured with an X-ray competency assessment test \[^9\] before and after three and six months of training (about 20 minutes per week). While large increases in detection performance were observed for the XRT training group, there were only small training effects for the other two CBT systems. Figure 3 illustrates the results broken up by prohibited items category for the comparison between XRT and one other CBT.

According to EU regulation, for classroom and/or CBT, at least six hours every six months are mandatory for X-ray screeners. While most, if not all, airports in Europe are compliant with this requirement, there are differences regarding its implementation.
Effectiveness and efficiency of CBT systems is one aspect. Regarding supervision and quality control, it is also important to ensure that the CBT libraries are periodically updated based on systematic threat assessment to keep training interesting and up-to-date. Setting goals on training achievement and analysing training data is also relevant for ensuring CBT effectiveness. I have seen airports where a CBT system has not been updated for several years with the consequence that screeners became bored. Some screeners simply clicked through images during training in order to achieve the required training hours knowing that no one would verify whether they reached higher training levels.

Certification Tests Must Be Reliable, Valid and Standardised
Certification using X-ray competency assessment tests is essential to ensure that screeners have acquired and maintained the required detection performance. European Regulation mandates recurrent certification at least every three years, while I still would recommend an annual or at least a bi-annual mode. This also provides a strong incentive for screeners to take CBT seriously. Regarding supervision and quality control, it is important to mention that the tests should be reliable, valid and standardised. How this can be achieved by following principles and requirements for assessing X-ray image interpretation competency has been defined in a white paper involving scientific, operational and regulatory experts [10]. This white paper has been adopted by the European Civil Aviation Conference (ECAC) and the International Civil Aviation Organisation (ICAO). While in some European countries the responsible appropriate authorities, airports and service providers know these principles and requirements and ensure their implementation, there are other countries where this is not the case yet. It is clear that harmonisation regarding this matter is crucial to achieving comparable competencies of screeners across European airports.

Threat Image Projection is Important for Attention and Motivation
As I pointed out in an article seven years ago [11], scientifically proven selection tests, effective CBT and high quality certification tests are important prerequisites for good operational X-ray detection performance, but they cannot guarantee it. The reason is simple: you could have screeners with great visual-cognitive abilities that have trained with an effective CBT and have passed certification, but they still fail a covert test because they were not attentive and/or motivated when the covert test was conducted. Threat image projection (TIP) can be a great tool for increasing attention and motivation [1, 12]. Visual attention research has shown that rare targets are frequently missed [13, 14]. With TIP, this problem can be reduced. Moreover, X-ray screening becomes much more interesting and motivating because, with TIP, screeners are exposed to the prohibited items they have to look for at work and because they receive immediate feedback on their performance.

Supervision and quality control is also very important for TIP. If a small image library is used without regular updates, screeners can become eagle-eyed at spotting TIP images resulting in high TIP scores that have little to do with covert test results [12]. Moreover, some (older) TIP software has projection algorithms that result in TIP artefacts, which can make the projected fictional threat items (FTI) almost pop out of X-ray images (e.g. unnatural colour blending and placement, no distortion and size correction of FTI). In order to fully benefit from TIP, a large image library with periodical updates should be used together with realistic projection of FTI. Ensuring that the recently updated EU Regulation on TIP is implemented properly is a prerequisite for TIP effectiveness.

Practical Tests (Covert and Overt) are Needed for Successful Inspections
Humans often fail to react correctly if something happens that they do not expect. How often covert tests are conducted has a large impact on covert test results [13]. Conducting covert tests on a regular basis, ideally in combination with overt tests (where screeners have to describe the content of X-ray images) as a training and quality control procedure is essential to achieving good results in airport inspections. This is of particular importance when TIP is used to avoid overreliance on TIP feedback messages, which can result in missing a covert test [14]. I have seen airports where covert and overt tests are conducted every week and screeners know that the probability of getting tested within a year is high. At other airports, covert and overt tests were conducted so rarely that screeners not only failed in airport inspections, because they simply did not expect covert tests, but they also failed overt tests for reasons of stress in a situation they were not used to.

Summary and Conclusion
Research conducted since 9/11 shows how X-ray screeners’ detection performance can be improved. The challenge lies in implementing the different processes and tools in a way that enables X-ray screeners to achieve good detection performance results. Other aspects have not been covered in this opinion piece. For instance, behavioural analysis can help in detecting malicious intent independent of the prohibited item carried and this can be combined with checkpoint screening. Risk-based approaches and unpredictability have large potential not only regarding detection and deterrence but also for increasing efficiency. X-ray machines with explosive detection for cabin baggage screening are extremely useful when taking into account that the human eye has difficulty in distinguishing certain explosives from benign organic material when conventional X-ray imaging is used. Creating smarter security checkpoints is great, but as long as they entail X-ray screeners, personal selection, effective training, performance measurement, feedback and motivating work design will remain of crucial importance in achieving good human-machine system performance.

Prof. Dr. Adrian Schwaninger is the head of the Institute Humans in Complex Systems (Miks) at the School of Applied Psychology of the University of Applied Sciences and Arts Northwestern Switzerland. He is also the chairman of the Center for Adaptive Security Research and Applications in Zurich (CASRA).

References