

Training of Airport Security Screeners

In this article Adrian Schwaninger continues his interesting series on aviation security human factors. He lectures at the University of Zurich and the Federal Institute of Technology Zurich. The main areas of his teaching and research activities are visual cognition, psychophysics, signal detection theory, research methods, object recognition, and visual attention. In close collaboration with Zurich State Police, Airport Division he has conducted several research projects, which were funded by Unique Zurich Airport, Safety and Security. Due to the keen request from our readers, we asked Dr. Schwaninger to continue his highly interesting and popular series.



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Current x-ray machines provide high resolution images, many image processing features and even automatic explosive detection. But the machine is only one half of the whole system. The last and most important decision is always taken by the human operator. In fact, the best and most expensive equipment is of limited use, if a screener finally fails to recognize a threat in the x-ray image. This is of special importance because according to several aviation security experts the human operator is currently the weakest link in airport security. This matter is being realized more and more and several authorities as well as airports are planning to increase investments into a very important element of aviation security: Effective and efficient training of screeners.

Indeed, reliable detection of prohibited items in x-ray images of passenger bags is not as easy as one would expect. Consider the images depicted in Fig. 1. The image on the left and in the middle show x-ray images of hand baggage. Each of them contains two prohibited items that could be used to kill a person. The bag on the right depicts an x-ray image of hold baggage with a bomb. In the ideal case each of these threat items would be detected by a screener reliably within a few seconds of inspection time. This article tells you how that can be achieved.

Scientific approach

In the last twenty years psychologists, neuroscientists and computer vision specialists have made much progress towards a deeper understanding of how the human brain recognizes objects. This knowledge is essential for building

a scientifically based training system that is effective and efficient and allows achieving an excellent level of detection performance.

Object recognition is a very complex process but essentially it means to compare visual information to object representations stored in visual memory. The ability to recognize an object class depends on whether itself or similar instance has been stored previously in visual memory. In other words, you can only recognize what you have learned. This explains why training is so important. Identifying the threat items in Fig. 1a and 1b is difficult without training because the objects are depicted in a view that is rather unusual in everyday life. Detecting a bomb such as in Fig. 1c is difficult for untrained people because usually we do not encounter bombs in everyday life. Therefore, a good training system must contain many forbidden objects in many viewpoints in order to train screeners to detect them reliably. Indeed, several studies from our lab and many others worldwide have found that object recognition is often dependent on viewpoint. Moreover, there are numerous studies from neuroscience suggesting that objects are stored in a view-based format in the brain.

As you can see in Fig. 2 the hammer, dirk, grenade and gun, which are visible in the bags of Fig. 1a and 1b are indeed much easier to recognize if they are shown in a view that is more often encountered in real life. Because you never know how terrorists place their threat items in a bag, airport security screeners should be trained to detect prohibited items from all kinds of different viewpoints. In a close collaboration with Zurich State Police, Airport division we have

Fig. 1 Detecting prohibited items in x-ray images is not easy without proper training.

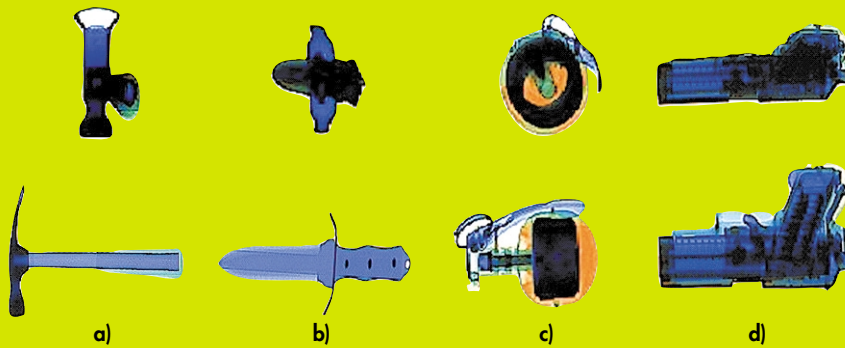


Fig. 2: Unusual views (above) are often more difficult to recognize (below).



Fig. 3: Relevant factors of threat detection.

- a) Rotated objects are more difficult to recognize (effect of viewpoint),
- b) when objects are superimposed by other objects, detection performance decreases (effect of superposition),
- c) identifying a threat item in a close-packed bag is more difficult (effect of bag complexity).

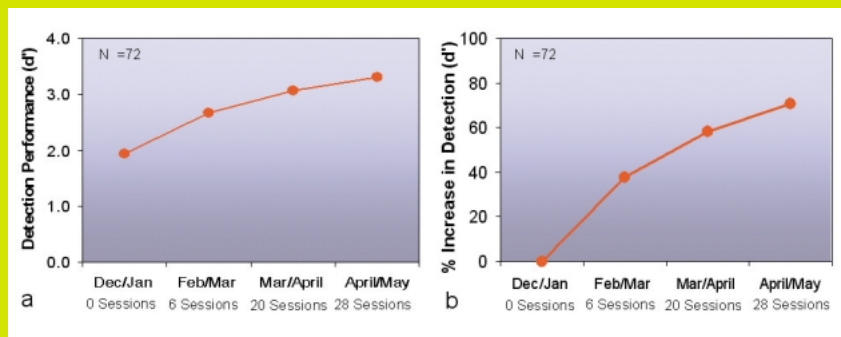


Fig.4: Results of a study, in which the effectiveness of X-Ray Tutor was evaluated.

- a) Detection performance measured by d' increased substantially as a result of training,
- b) The relative increase in detection performance was 71 % when compared to the first measurement (average from 72 screeners) For a subgroup of 52 screeners the average increase in detection performance was even higher, i. e. 84 %.

Note: At test always new bombs were used, which had not been shown in previous training sessions.

developed a system in which each object is saved in 6 basic views. This basic view set has been derived from object recognition studies and varies for different object classes. Using image processing algorithms plane rotated versions and mirror reversals can be created in the proprietary Heimann Image Format (HIF) as well as in standard image formats such as BMP, JPG, GIF or PNG. The current version of the library contains 236 prohibited items and each of them can be displayed in 6 basic views x 3 plane rotations x 4 mirror reversals = 72 views. This results in a total of 236 prohibited items x 72 views = 16'992 x-ray images. Of course it is not necessary to show each screener all these images. But a good training system should determine for each

screener individually which views are difficult. Based on an individual diagnosis the system should create individual training sessions in order to enable the screener to achieve a reliable detection performance even if threat items are substantially rotated away from the easiest view.

X-Ray Tutor training system

In order to bridge the gap between science and application there has to be a close collaboration between scientists, airport security specialists and companies who develop x-ray equipment and training systems. Since June 2000 there is a close collaboration between vision scientists from the University of Zurich and aviation security specialists from Zurich State Police, Airport

Division. Several scientific studies have been conducted, which were financially supported by Zurich Airport and provided important insights for different human factor aspects in aviation security. Since 2002 there is a good cooperation with Smiths-Heimann and Security Training International (STI), who provided useful technical information from the vendor side. The good relationship between these different partners made it possible to develop a new training system ("X-Ray Tutor"), which is based on scientific findings from visual cognition, object recognition, and signal detection theory. It is operational since last year at Zurich Airport and since this year at 14 airports in Germany.

For the remaining of this article I will focus on efficiency and effectiveness. These topics were of special importance for the development of X-Ray Tutor and are of general interest for training security screeners using CBT. For detailed information on X-Ray Tutor either contact us directly (see BusinessPartner section Terminal Solutions), or Security Training International (STI), or Safe Passage International (SPI).

Efficiency and individually adaptive training

Remember how it was at school when there was one teacher per class-room. Some pupils were always bored, because they were somehow cleverer than others. For some others, the lessons were always too difficult and they were often frustrated. These problems can be avoided nowadays if computer-based training is used that adapts to each individual. The individually adaptive system should start with easy images and increase image difficulty based on the results in individual training sessions. Scientific studies conducted at our lab have shown that image difficulty depends on three image-related factors (Fig. 3): Viewpoint of the prohibited item, superposition by other objects and bag complexity. As explained above, objects are more difficult to recognize if they are depicted in unfamiliar views. Additionally, a prohibited item is more difficult to recognize if it is superimposed by other objects. Finally, bag complexity challenges the visual processing capacities and threat items are usually more difficult to detect in close-packed bags. Interestingly, there are remarkable differences between screeners regarding how well they can cope with these three effects. For more information on this topic see the article in AIRPORT 2/2003, p. 14-15.

In order to be efficient a training system should be individually adaptive. Training costs time and money and this should be spent optimally. Therefore, X-Ray Tutor focuses on training the

recognition of threat items and views that are hard to recognize on an individual basis. For each prohibited item and trainee, view difficulty, superposition and bag complexity is increased based on the achievements during training sessions. It is not necessary to show each item in all 72 viewpoints mentioned above. But X-Ray Tutor shows for each screener preferentially those views, which need to be trained especially. Priority is first given to achieve a view-independent detection performance. Then the screener learns to recognize the prohibited items in increasing levels of superposition and bag complexity. This is achieved by using image processing algorithms that provide objective measures of superposition and bag complexity. These measures have been shown to be valid, because they correlate with human detection performance.

Scientific evaluation of effectiveness

In order to evaluate the effectiveness of X-Ray Tutor we have conducted a study with 72 screeners that had not been trained on bomb

detection before. The training was conducted with X-Ray Tutor HBS in sessions of 20 minutes at least once a week during 6 months. Every 4-6 weeks the participants took a test in which bombs had to be detected that they had never seen before. A latin square counterbalanced design was used with four tests of equal difficulty and four groups of participants with similar detection performance. Fig. 4a shows how detection ability increased as a result of training. In order to measure training effectiveness we calculated percent increase of detection performance relative to the first test. As you can see in Fig. 4b the training with X-Ray Tutor resulted in a relative increase of detection ability by almost 60 % after 20 training sessions and 71 % after 28 training sessions. Remember that at test the screeners had always to detect bombs they had never seen before! Moreover, for a subgroup of 52 screeners, who on average took 31 training sessions during the period of six months, the relative increase in detection performance was even higher, i.e. 84 %.

Thus, training with X-Ray Tutor was indeed very effective. Moreover, average response times for detecting a bomb during training decreased from 8 seconds to only 4 seconds. In other words, after training with X-Ray Tutor the screeners were able to detect bombs reliably within a few seconds of inspection time. The participants became also faster when innocent bags were shown. Average response times during training decreased from a maximum of 12 seconds to only 7 seconds.

In short, reliable detection within a few seconds and low false alarm rates; that's what the human brain can achieve easily when trained appropriately.

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