Selection and Pre-Employment Assessment of Aviation Security Screeners

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For years, terrorist attacks have presented a constant threat to civil aviation and highlighted the importance of aviation security. Threats that have reached new dimensions demand a reliable security check, not only for hold baggage but also for passengers and their carry-on baggage. For example, the terror attack on September 11, 2001, has revealed a new dimension. Former terror attacks were comparable to Lockerbie 1988, when Pan Am Flight 103 was destroyed by a bomb in the hold baggage. As a result, immediate changes regarding hold baggage screening were introduced, and automated systems for detecting improvised explosive devices (IEDs) in hold baggage were developed. However, in the recent past, suicide bombings have become more likely, and therefore enhanced security checks of passengers and their carry-on bags have become necessary.

Although new state-of-the-art technology, such as automatic liquid detectors, millimeter wave systems, X-ray machines with automatic detection of explosive materials, and so forth, facilitate the detection of threat items, the final decision is still made by human operators (screeners). It has been argued that with advances in technology, the cognitive demands on humans are increased rather than lowered.¹

While procedural and predictable tasks can be carried out by machines, the human operators are still indispensable for tasks that require inference, diagnosis, judgment, and decision making. In aviation security, the human operator is a critical decision maker and probably the most capable and adaptable resource in the system. Above all, now that changes in regulations cannot be anticipated in many cases and have to be implemented within a short period of time (e.g., the liquid regulation after the terror plot in London 2006 was uncovered), the human operator is an essential component of aviation security. Nevertheless, he/she can also be the weakest link if not skilled or trained enough. The challenge in aviation security is to ensure maximum security while keeping the workflow at checkpoints efficient. Moreover, a reliable security check demands sufficient time and human resources, which is sometimes in

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conflict with the commercial pressure that security companies are facing. In order to increase security and efficiency, relevant factors in the security process should be evaluated by means of a job and further task analysis. Once the job requirements are defined, reliable and valid measures can be developed to increase security and efficiency.

Furthermore, analyses should investigate whether the measured factors relate to relatively stable abilities and aptitudes or to training effects. The more clearly the relationship between abilities, aptitudes, and acquirable knowledge is defined, the better the selection criteria will be. Factors that cannot be trained should be addressed by a preemployment assessment procedure to ensure that only people who have the capabilities needed to fulfill the job requirements are employed.

In this chapter, we describe the main results of various studies of the selection and preemployment assessment of screeners. We start by explaining how a job and task analysis can be applied in order to define the relevant job requirements and further define selection, competency assessment, and training criteria.

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**Job and Task Analysis to Define the Important Tasks at Security Checkpoints**

**Job and Task Analysis**

Job and task analytic techniques are useful tools to understand the context in which the human operator’s work is taking place. A job and task analysis should be performed primarily in order to identify the important tasks and responsibilities of a specific job. The job and task overview then provides a clear description with which to define the most important tasks. These should further be analyzed by means of a traditional or cognitive task analysis (CTA), depending on the task demands.

The methods that can be used to perform a job or task analysis are similar to each other, and they should be chosen carefully in order to best match the goals. Generally, two data collection techniques can be distinguished: subject- and observation-based techniques. That is, inputs from persons who are familiar with the task can be collected using verbal protocols and questionnaires (subject-based) or experts can be observed on the job (observation-based).
Subject-based methods include among others the critical incident technique (CIT), questionnaires, interviews, and verbal protocols. The CIT was developed by John Flannigan and is a widely used method in which critical incidents are reported using questionnaires or interviews. These incidents involve human behaviors that have critical significance to the task. Activity sampling and observations are observation-based data collection techniques. Activity sampling is a method that collects information about the time spent on employees’ activities. Therefore, a large number of observations are made over a period of time. It is also suggested that observations and unstructured interviews are best used as part of a preliminary task analysis. The data analysis should also be in line with the goals and match the data collection. Results can be visualized with charts, summarized using statistical methods, or presented in a verbal report.

Job and Task Analysis at the Security Checkpoint: An Example

In this section we report a primary job and task analysis in the field of aviation security as an example. At most airports there are three areas/workplaces: cabin baggage screening (CBS), hold baggage screening (HBS) and cargo screening. All screeners are assigned to one workplace only. Because of the separated workplaces and slightly varying tasks, CBS and HBS were examined separately in order to identify the primary job tasks. For cargo screening, no job analysis was performed. In this chapter we report our findings for CBS only.

The major task of aviation security screeners is a reliable security check of passengers and passenger bags to ensure that no threat items or dangerous goods are brought into the security restricted area or on board the aircraft. Furthermore, this check should be done as efficiently and in as customer-friendly a way as possible. For the job analysis in CBS, a subject- and observation-based data collection method was chosen. That is, inputs from persons who were familiar with the task were collected, and observation methods were applied by professionals. First, professionals observed aviation security screeners at their workstation. Further, unstructured interviews with screeners were conducted regarding the primary tasks they have to fulfill. Based on these inputs the security check can be reported as follows.
As can be seen in Figure 1, the security check of passengers and their carry-on bags is conducted by a crew that consists of four to six screeners. Each screener works at an assigned position for a defined period of time. Normally after 20 to 30 minutes, positions are changed. Each position is linked to a specific task. Besides the body and baggage check, X-ray screening of passenger bags (see Figure 1, position 2) is one of the most important tasks at the checkpoint, since missing a threat item in a passenger bag could have terrible consequences. Note that if a screener is not effective in the visual inspection of X-ray images and therefore sends too many harmless bags to be hand-searched, long waiting lines at the checkpoint will occur. Many objects look quite different in X-ray images than in reality. Thus, for the screening process, visual abilities and knowledge of the visual appearance of threat items in X-ray images could be assumed to be rather important determinants in achieving a certain level of security without sacrificing efficiency in X-ray screening. If the screener decides that a piece of baggage has to be hand searched, another screener (see Figure 1, position 3) is responsible for hand searching the bag.

For this task, language and communication skills are needed, because screeners have to ask the passenger whether they can manually inspect the bag and sometimes communicate with the passenger to find out what certain items are used for. In addition, the conversation with the passenger can provide information on whether the passenger and/or the bag might be a threat.
Passengers could also try to bring prohibited items into the security restricted area and the airplane by wearing them on their body. Therefore, at minimum one female and one male screener are responsible for the body check (Figure 1, position 4). At most airports, the body check is done by means of a metal detector and sometimes an additional manual body search. In coming years, this manual body search might be replaced by new technology (e.g., millimeter wave systems). Millimeter wave technology allows the scanning of people for the presence of threat objects. As clothing and other organic materials are translucent, an image of the passenger can be provided, which can then be interpreted. Whether this body search is done manually or using millimeter wave systems, specific abilities should be considered for both approaches.

Another position is in front of the X-ray machine (Figure 1, position 1). The assigned screener has the responsibility to inform passengers about the security check and place their bags on the belt. This is done by the screener to ensure that terrorists cannot place the bag on the belt in a way that would make it more difficult to detect a threat item (for example, because it would reappear in a difficult view in the X-ray image (Figure 3, for which see below, will provide an example). In addition, this procedure ensures also that the distance between two bags is large enough and thus enough time is provided to the operator who has to interpret the X-ray image.

For nearly all positions in the CBS area, dealing with passengers is important. As a result, communication between aviation security screeners and passengers can be assumed to play a key role in ensuring an efficient workflow. Hence, language and communication skills as well as customer service skills were defined as basic job requirements. Moreover, a crew always consists of several screeners who have to work as an efficient team, not only during normal operations but especially in stressful situations. This factor becomes even more important taking into consideration the fact that screeners are randomly assigned to a crew and especially at bigger airports do not know each other very well. Furthermore, passengers are often not pleased to have to pass through security control, and therefore screeners have to be very patient and need the ability to cope with negative feedback even if they do their job very well.

In summary, the job analysis revealed X-ray screening, baggage search, body search, dealing with passengers, teamwork, and coping with negative feedback to be important for airport security screeners working in the CBS area.
Cognitive Task Analysis in X-Ray Screening

Based on the job analysis, the abilities, aptitudes, and knowledge that are needed to perform the tasks proficiently should be identified. Depending on the task, a traditional (behavioral) task analysis or a cognitive task analysis (CTA) can be applied. Whereas the traditional task analysis focuses mainly on noncritical procedural tasks, the CTA identifies and describes cognitive elements, processes such as decision making, problem solving, and so on, as well as the knowledge and skills that are required for similar job components. Behavioral task analysis describes the task in terms of time spent, criticality, and frequency. In contrast, CTA should be used for high-performance tasks that require large amounts of knowledge or information, significant decision making or problem solving, heavy workload or time pressure, multitasking, situations that change substantially, or considerable amounts of teamwork. Generally, these cognitive processes are more difficult to study because they are not directly observable. Traditional task analysis and CTA can also be used as complementary tools. Usually traditional task analyses are used to specify the basic job tasks and precede the CTA.

Quite often a CTA includes a comparison of novices and experts, to find out which skills and knowledge are domain specific. These findings can help to identify selection criteria for required skills and define the training sessions needed to acquire job specific knowledge and procedures.

CTAs can be conducted using either research or operational methods. Although research methods are often considered too complex and time consuming in operational settings, they can be very useful if the field of application is very broad and relatively unknown. The methods used to collect and analyze the data are the same as described above for the job and task analysis. The results of the analysis can then be implemented within a few weeks or months. The final report should provide a clear description of the CTA. This should include the objective of the CTA, job description, analyzed tasks, participant selection, materials and procedures used for data collection, data analyses, results, and conclusion.

As an example, we performed a CTA for the X-ray screening task, which is considered to be one of the most important tasks at airport security checkpoints. First, a primary data collection was conducted, to describe the cognitive structures and processes underlying the X-ray screening task. Based on this information, data collection and analysis were performed...
using various research methods. As the job analysis was previously reported, we focus here on the description of the CTA.

**Primary Data Collection Regarding the X-Ray Screening Task**

Often, screeners have only a few seconds to decide whether an X-ray image of a passenger bag contains a threat item or not. At security checkpoints it is of the utmost importance that threat items can be detected quickly and reliably without sacrificing efficiency. If too many bags are wrongly judged as not “OK” and have to be hand searched, long waiting lines at checkpoints can be the result. The X-ray screening task demands a knowledge of which items are prohibited and what they look like in X-ray images, certain visual cognition abilities, decision making, and often multitasking under time constraints. Because of these factors, a CTA is recommended. The CTA presented here focuses on the visual inspection task only.

In a first step, unstructured interviews, verbal reports, and observations were conducted for the primary data collection. The results of these data collection techniques as well as theories from basic research studies in object recognition allowed us to assume that the screening process involves both knowledge-based and image-based factors.

![Prohibited items (I)](image-url)
Knowledge-based factors refer to knowing which items are prohibited and what they look like in X-ray images.\textsuperscript{11} Often X-rayed objects like the electric shock device depicted in Figure 2a look quite different than they do in reality. Certain threat items look like harmless objects but are in fact threat items that are not allowed on board an airplane (see, for example, the knife in Figure 2b). Other objects, like the improvised explosive devices (IEDs) in Figure 2c, are normally not seen at checkpoints and are therefore more difficult for screeners to recognize if they have not received appropriate training.

![Figure 3 Prohibited items (II)](image)

It has been pointed out that bag complexity, superimposition, and viewpoint of threat items in X-ray images can influence detection performance (see Figure 3 for examples).\textsuperscript{12} The detection of a gun becomes more difficult if there are many other objects in the bag that distract attention from it (high bag complexity). If other objects in the bag are superimposed on the gun or if it is shown in an unusual view, detection also becomes more difficult. These have been defined as image-based factors in X-ray screening.\textsuperscript{13} Bag complexity, superposition, and the viewpoint of threat items are related to visual cognition processes such as visual search, figure-ground segregation, and mental rotation. Visual search studies have revealed that it becomes harder to detect a target object if many objects are presented within a scene.\textsuperscript{14} Detection is more difficult if other objects are superimposed on the target object and relevant components are not visible.\textsuperscript{15} Finally, viewpoint-dependent theories in object recognition predict the systematic
effects of viewpoint and familiarity. The term “canonical” refers to the viewpoint that is easiest to recognize. This is related to the number and diagnosticity of the features that are visible but also to how often an object is encountered in a certain view. Different views of an object can be stored in visual memory to facilitate recognition despite changes in viewpoint. However, people with good mental rotation abilities are probably more able than others to detect a prohibited item when it is shown in a rotated view that they have not seen before.

In state-of-the-art X-ray screening equipment, different materials in X-ray images (organic, metallic materials, etc.) are coded using different colors. Therefore, it can be assumed that a color vision deficiency can impair the task of interpreting the X-ray image. There are different kinds of color deficiencies that are genetically determined. The most common form is the red/green color blindness, which occurs in about 8 percent to 12 percent of males and about 0.5 percent of females.

### Materials and Procedure

#### Knowledge-based Factors

An important factor in the X-ray screening task is knowledge of which items are not allowed in the security restricted area and what they look like in X-ray images. To measure whether such knowledge-based factors could in fact be improved with on-the-job experience or specific training, the X-Ray Prohibited Items Test (X-Ray PIT) was developed. This test includes all kinds of prohibited items according to international prohibited items lists (EU, ECAC, ICAO). To keep the image-based factors relatively constant, all items are shown in the easy view in bags of medium complexity with medium superposition by other objects. In the X-Ray PIT a total of 160 trials are shown to participants; 80 of the images are harmless bags (i.e., without any prohibited item). Each image is shown for 10 seconds on the screen. For each X-ray image, participants have to decide whether the bag is OK (no prohibited item contained) or NOT OK (the bag contains a prohibited item) by clicking on the appropriate button on the screen. Participants also have to indicate to which category the prohibited item(s) belong(s) and how sure they are in their decision. More information about this test and its reliability and validity measures can be found in Hardmeier, Hofer, and Schwaninger (2006).
Image-based Factors

The X-Ray Object Recognition Test (X-Ray ORT) was developed in order to measure how well people can cope with the effects of viewpoint, superposition by other objects, and bag complexity. This test includes a total of 256 X-ray images of passenger bags. In this test, only guns and knives, object shapes that are well known by novices, are shown. All the X-ray images are displayed in grayscale, as the meaning of color in X-ray images is not known by novices. All three image-based factors in the test are varied systematically. A total of eight different guns and eight different knives are used. All of them are shown in an easy and rotated view. Each of these items is then placed in a bag, once in a bag with high complexity level and once in a bag with low complexity level, that is in a bag with high superposition by other items and in a bag with low superposition by other items. Thus, all the factors are combined with each other and each threat item is shown once in each possible combination. The X-Ray ORT is a computer-based test that is very easy to use. Test participants receive a short introduction that explains the test, as well as some exercise trials to familiarize them with the test-taking procedure. In order to ensure that the object shapes are known, all the guns and all the knives are shown for 10 seconds on the screen before the test starts either in the frontal or in the rotated view. All images are displayed for four seconds only on the screen in order to simulate a busy security checkpoint situation. For each X-ray image, participants have to indicate whether the bag is OK (i.e., it contains no gun and no knife) or NOT OK (i.e., it contains a gun or a knife), by clicking on the appropriate button on the screen. Additionally, participants have to indicate how sure they are in their decision, by using a slider control.20 The test itself is subdivided into four parts, and after each part participants can take a short break if desired.

Procedure

To investigate whether knowledge-based and image-based factors can be distinguished, the detection performance of experts and novices was compared in the X-Ray PIT (rather knowledge-based factors) and the X-Ray ORT (image-based factors). There was an expectation of larger differences between the groups for the X-Ray PIT because the knowledge of which items are prohibited and what they look like in passenger bags has to be acquired through experience and training.21 As explained above, the X-Ray ORT is assumed to measure how well
someone can cope with image-based factors such as the effects of viewpoint, superposition, and bag complexity. Schwaninger and colleagues assumed such abilities to be relatively independent of training and experience. To test these hypotheses, the detection performance in both tests of aviation security screeners was compared with the detection performance of novices. Then, the performance of aviation security screeners in both tests was compared before and after two years of individually adaptive computer-based training (CBT). Further, correlations between the X-Ray ORT (representing on-the-job performance) and the PIT (representing theoretical knowledge) were compared. Finally, the detection performance of screeners who were employed using the X-Ray ORT as a preemployment assessment tool and screeners who were employed without using the X-Ray ORT was compared.

**Participants**

The results that are going to be presented here are based on 453 aviation security screeners aged between 24 and 65 years ($M = 48.94$ years, $SD = 9.09$ years). A total of 134 novices aged between 21 and 26 years ($M = 23.24$, $SD = 1.22$) and 101 job applicants aged between 19 and 55 years ($M = 35.25$, $SD = 9.79$) who were employed using the X-Ray ORT as a preemployment assessment tool were tested. Depending on the analysis, the sample size had to be adjusted.

**Data analysis**

Signal detection provides valid measures of the detection performance of screeners, taking the hit rate and the false alarm rate into account. A hit is a correctly identified threat item, whereas sending a harmless bag to be hand searched is called a false alarm. Missing a threat item is defined as a miss and a correctly identifying a harmless bag is called correct rejection.
Figure 4 shows why the hit rate alone is not a valid detection performance measure. For example, screener B in Figure 4 reaches a hit rate of 90 percent by simply judging most bags as NOT OK. This becomes apparent when considering his false alarm rate, which is nearly 80 percent. In contrast, screener A reaches the same hit rate, but with a very low false alarm rate (about 10 percent). Thus, screener A achieves a high level of security without sacrificing efficiency. The detection performance measures $d'$ and $A'$ take the hit and false alarm rate into account. The outcome $d'$ equals $z(p_{\text{Hit}}) - z(p_{\text{FA alarm}})$, whereas $p_{\text{Hit}}$ refers to the hit rate, $p_{\text{FA}}$ to the false alarm rate, and $z$ to the $z$-transformation (see Green and Swets 1966). The outcome $d'$ of screeners is related to the receiver operating characteristics (ROC) curves that can be seen in Figure 4. These curves show how the hit rate of a screener changes as a function of changes in the false alarm rate. As an example, $d'$ of screener A with 2.5 is much higher than $d'$ of screener B with 0.5. The detection performance measure $d'$ is assumed to be independent of subjective response bias.

The response bias can vary depending on the personality of the screeners, the subjective and objective costs and benefits of the response, target prevalence (i.e., how often threat items occur), and other factors. As a consequence, the response bias can change quickly, while changes of $d'$ require much more time and are related to the selection and training of security screeners. A terrorist attack would result in an immediate change of the response bias, but $d'$ scores would remain relatively unaffected according to signal detection theory. This is illustrated in Figure 4 for screeners A and B. Both of them would immediately send more bags
to be hand searched (judged as “NOT OK”) after a terrorist attack. This would result in higher hit rates but also higher false alarm rates. Thus, while screeners change their position on their ROC curve (change in response bias), they remain on the same curve (their $d'$ remains the same). In order to create a basis of comparison, all results in this chapter are calculated using $d'$.

**Results**

**Effect of Experience and Training on Knowledge-based Factors and Abilities to cope with Image-based Factors**

In order to examine whether experience affects knowledge-based factors and abilities to cope with image-based factors, previous tests looked at the detection performance of experienced aviation security screeners and novices in the X-Ray PIT and the X-Ray ORT. The results showed that detection performance differed remarkably between experts and novices in the X-Ray PIT, but only little in the X-Ray ORT. This difference becomes even more evident if the relative difference between experts and novices is computed using the following formula:

$$\frac{\text{Detection Performance}_{\text{Experts}} - \text{Detection Performance}_{\text{Novices}}}{\text{Detection Performance}_{\text{Novices}}}$$

As can be seen in Figure 5a, the percentage difference between experienced screeners and novices was 94 percent in the X-Ray PIT and only 31 percent in the X-Ray ORT. A detailed analysis for image-based factors revealed that the detection performance decreased significantly if threat items were shown in close-packed bags, had other items in the bag superimposed on them, or were shown in an unusual view (see Figure 5b and 5.5c). Although experienced screeners perform at a higher level than novices, large differences in terms of viewpoint, superposition, and bag complexity were found among individual screeners, whether they were experienced or novices. For both groups, large differences between individuals were found as indicated by the standard deviations in Figure 5b and 5.5c.
In summary, it was found that experience results in better detection performance in the X-Ray PIT, which measures whether screeners know which items are prohibited and what they look like in X-ray images (knowledge-based factors). In contrast, experience does not result in large increases in the X-Ray ORT, which rather measures the visual abilities needed to cope with image-based factors such as viewpoint, superposition, and bag complexity.

![Figure 5 Differences in detection performance](image)

Several scientific studies have shown that computer-based training can be a powerful tool to increase the X-ray image interpretation competency of screeners. First, some threat items are very rarely encountered at checkpoints (e.g., bombs). Second, other prohibited items look quite different in the X-ray image than in reality (e.g., the electric shock device in Figure 2). An individually adaptive training system that includes all kinds of prohibited items in different views investigated whether such training (20 minutes twice a week) affects knowledge-based factors and abilities to cope with image-based factors differently.
As can be seen in Figure 6a, the detection performance of experienced but untrained aviation security screeners (first measurement) is generally lower than the performance of trained screeners (second measurement) in both tests. Further, detection performance increase was higher for the X-Ray PIT than for the X-Ray ORT. The relative difference for the X-Ray PIT was 85.0 percent, but it was only 22.7 percent for the X-Ray ORT (see Figure 6b).

Thus, an individually adaptive CBT can strongly increase the knowledge of which items are prohibited and what they look like in X-ray images and result in better detection performance of screeners. In contrast, the abilities to cope with image-based factors such as viewpoint, superposition, and bag complexity are influenced by training only to a limited extent. Therefore, it could be valuable to use a test such as the X-Ray ORT as part of the preemployment assessment procedure, in order to select people who have the visual abilities to cope with the image-based factors needed in X-ray screening.

The X-Ray ORT as Preemployment Assessment Tool

The rather small difference in the X-Ray ORT between novices and experienced aviation security screeners as well as between trained screeners and those who are experienced but not trained supports the assumption that this test measures relatively stable visual abilities needed in X-ray screening. Compared to knowledge-based factors, these abilities can only be increased to a limited amount through experience and training. Therefore, the X-Ray ORT could be a useful instrument for preemployment assessment purposes. Before applying this test to job applicants, the X-Ray ORT was validated. A medium correlation between both X-ray
screening tests was expected as both tests deal with X-ray images. The X-Ray PIT measures mainly the knowledge of prohibited items in X-ray images, as image-based factors were kept relatively constant.

Nevertheless, in the X-Ray PIT abilities to cope with image-based factors plays along as well. However, the CBQ, which is a multiple-choice test about airport-specific issues and procedures at airports should show a lower correlation with the X-Ray ORT. Further, test results in the X-Ray ORT were correlated with TIP data. TIP is a technology that allows us to measure detection performance on the job by projecting fictional threat items into real passenger bags. After each TIP image, screeners receive a feedback message that a fictional threat item was present. TIP data for 86 aviation security screeners were aggregated over a period of 17 months.

If abilities to cope with image-based factors is in fact important for the X-ray screening task, screeners with high abilities should also show a better detection performance on the job. Indeed, there was a rather high correlation ($r = .62$) between the X-Ray ORT and the X-Ray PIT (see Figure 7a). As expected, there was only a small correlation between the detection of prohibited items in X-ray images and theoretical knowledge of airport-specific issues ($r = .25$), which was measured with the CBQ, a multiple-choice test (Figure 7b). Regarding TIP data, a medium to high correlation ($r = .51$) between detection performance in the X-Ray ORT and on-the-job performance was found (Figure 7c).

Based on these results, it was concluded that the X-Ray ORT is a valid instrument that can account for a part of the detection performance variability and therefore should be used as a preemployment assessment tool to select job applicants. A total of 101 job applicants who passed the preemployment assessment successfully were employed as aviation security
screeners. All of them had to reach a defined score in the X-Ray ORT, was above the average detection performance level. Further, job applicants had to pass the color blindness test, an English and German language test, a physical examination, and a job interview. Whether the X-Ray ORT in fact helps to improve the detection performance of aviation security screeners later on the job was also investigated. The detection performance in the X-Ray PIT of screeners who were employed with the X-Ray ORT and the performance of screeners who were employed without the X-Ray ORT were compared. Screeners who were not employed using the X-Ray ORT had working experience of between 2 and 26 years ($M = 9.71$, $SD = 5.50$ years). Screeners who were all hired as aviation security screeners based on the test results in the X-Ray ORT had a maximum of one year of working experience when taking the X-Ray PIT. The results show a significant difference between these two groups in terms of their performance measure $d'$ (see Figure 8). Thus, if the X-Ray ORT was used as an additional selection criterion as part of the preemployment assessment procedure, detection performance measured one year later using the X-Ray PIT was increased significantly.

![Figure 8 X-Ray ORT impact](image-url)
Conclusion

All results support the assumption that abilities to cope with image-based factors and knowledge-based factors are important determinants in the X-ray screening task. The hypothesis that image-based factors (bag complexity, superposition, viewpoint) are related to visual abilities that are not very dependent on experience and training was verified. The detection performance decreased with increasing bag complexity, superposition, and unusual viewpoint of threat items for experienced and trained aviation security screeners as well as for novices. Further, large individual differences within all three groups could be found.

That means that there are large differences between people in their abilities to cope with image-based factors, and these differences are still evident after weekly recurrent computer-based training over several months. Further analyses could show that results in the X-Ray ORT correlates with the detection performance in the X-Ray PIT and above all with TIP data, a measure of operational performance. Therefore, the abilities to cope with image-based factors should be defined as a basic job requirement and be measured within a preemployment assessment procedure. Whether detection performance can in fact be increased using the X-Ray ORT as a preemployment assessment tool was investigated in a second step. The results showed that screeners who were selected with the X-Ray ORT showed a significantly better detection performance after one year of employment compared to screeners who were not hired using the X-Ray ORT. Besides the abilities to cope with image-based factors, the knowledge of the visual appearance of threat items is essential. In comparison with experienced aviation security screeners, novices showed a poor performance in detecting prohibited items in X-ray images of passenger bags. Thus, the knowledge of what threat items look like can be learned with experience and on-the-job training. A follow-up study found that individually adaptive computer-based training can substantially increase the detection performance of aviation security screeners that is related to knowledge-based factors, that is, they show better knowledge of which items are prohibited and what they look like in X-ray images of passenger bags.
General Discussion

This chapter could show how useful a task and cognitive task analysis is in understanding a specific task like X-ray screening. The task analysis revealed that the job of an aviation security screener includes various tasks that should be taken into account when job applicants are employed. Besides X-ray screening, baggage and body search, dealing with passengers, teamwork, and coping with negative feedback were found to be important for screeners working in the CBS area. Similar requirements could be found for the HBS area. A CTA was performed for the X-ray screening task, which is supposed to be one of the most important tasks at security checkpoints.

As could be seen, X-ray screening includes various factors that should be taken into account when employing and training aviation security screeners. Whereas knowledge-based factors should be taken care of through training, the cognitive abilities needed to cope with image-based factors in X-ray screening, such as viewpoint, superposition, and bag complexity, should be tested as part of a preemployment assessment procedure. The X-Ray ORT is a reliable and valid instrument to measure abilities to cope with bag complexity, superposition, and rotation of threat items (effect of viewpoint) in X-ray images. Further studies should clarify whether the remaining defined tasks, such as baggage and body search, dealing with passengers, teamwork, and coping with negative feedback, are more related to abilities and have to be clarified within a preemployment assessment or can be learned on the job.

Acknowledgment

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References


1. Ibid.

2. Ibid.

3. Ibid.

4. Ibid.

5. Ibid.


13. There is no treatment for color vision deficiencies, since they are caused by missing or incorrect visual pigments. The genetically determined red–green color blindness affects men much more often than women, because the genes for the red and green color receptors are located on the X chromosome, of which men have only one and women have two. Thus, males are red-green color blind if their single X chromosome is defective. Women are color blind only if both X chromosomes are defective.


15. For the analysis of detection performance only OK and NOT OK responses were taken into account.


18. Ibid.


23. Ibid.

24. Ibid.