Airport Security Screeners Expertise and Implications for Interface Design

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Abstract
This paper describes research investigating expertise and the types of knowledge used by airport security screeners. It applies a multi method approach incorporating eye tracking, concurrent verbal protocol and interviews.

Results show that novice and expert security screeners primarily access perceptual knowledge and experience little difficulty during routine situations. During non-routine situations however, experience was found to be a determining factor for effective interactions and problem solving. Experts were found to use strategic knowledge and demonstrated structured use of interface functions integrated into efficient problem solving sequences. Comparatively, novices experienced more knowledge limitations and uncertainty resulting in interaction breakdowns. These breakdowns were characterised by trial and error interaction sequences.

This research suggests that the quality of knowledge security screeners have access to has implications on visual and physical interface interactions and their integration into problem solving sequences. Implications and recommendations for the design of interfaces used in the airport security screening context are discussed. The motivations of recommendations are to improve the integration of interactions into problem solving sequences, encourage development of problem scheme knowledge and to support the skills and knowledge of the personnel that interact with security screening systems.

Keywords
Airport Security; Eye Tracking; Intuition; Expertise; Interface Design

In the airport security context, x-ray screeners are required to detect broad and ambiguous categories of threat objects. Successful detection of these threats requires specific knowledge of an indeterminate variety of objects, and the appearance of these objects under x-ray conditions (Schwaninger, Hardmeier, & Hofer, 2005). Research investigating the performance of x-ray screeners has generally focussed on assessing visual knowledge and object identification. Studies have found that superior visual knowledge enables more effective threat detection, and as such, experienced security screeners generally outperform novice and naive screeners in terms of speed and accuracy of detection (e.g. Liu & Gale, 2011; Schwaninger et al., 2005). These general performance increases, however, have been found to be influenced by specific image circumstances that vary naturally in the activity context. When natural image variations were introduced such as clutter and rotation of objects, experts only moderately outperformed naïve observers (Schwaninger et al.,
This suggests that although visual knowledge is important, additional knowledge and skills are required for effective security screening.

To help support threat detection during these difficult image conditions security screeners have access to a number of image enhancement functions (IEFs). IEFs are visual enhancements that change the appearance of x-ray images in order to clarify or highlight certain areas of the image (Michel, Koller, Ruh, & Schwaninger, 2006). For example, an organic stripping filter removes objects composed of organic matter and a metallic only filter shows only metallic objects. While these enhancements are designed to aid threat detection, their effectiveness is debated, with a number of studies finding that IEFs actually reduced detection performance (e.g. Klock, 2005; Michel et al., 2006). A common practice of this research is to perform experiments under simulated conditions (e.g. Hardmeier, Hofer, & Schwaninger, 2005; Liu & Gale, 2011; Michel et al., 2006) where participants are not given the option to select relevant IEFs based on situational requirements. Instead, pre-set IEFs are used for the entirety of the experiment. The results from these studies are useful for showing that certain IEFs are ineffective under certain image conditions. For instance, the metallic only filter is ineffective for identifying organic objects (Klock, 2005; Michel et al., 2006). However, they do not provide significant insight into the human factors that contribute to the effective use of interface functions in real world situations. It is likely that experience, knowledge and personal preference have implications on interface interactions and their integration into effective problem solving.

While detailed investigation of expertise has not been thoroughly conducted in the airport security screening context, it has been explored in domains that share similar complexities (e.g. firefighting, military and nursing). This research falls in the category of Naturalistic Decision Making (NDM) research, which looks to understand expert decision making in real world situations characterised by uncertainty and dynamic conditions (Klein, 1998). In these complex environments experts are found to effectively overcome environmental and task complexity as a result of domain specific knowledge and experience (Klein & Hoffman, 1992). As experience is gained in a task domain, task specific mechanisms are refined and previously effortful actions become automatic and effortless (Ericsson & Towne, 2010).

The aim of this research is to investigate the role of expertise in airport security screening. This paper will identify and discuss the knowledge used by security screeners and the implications this has on interface design.

Investigating Intuitive Expertise

Investigations of expertise have traditionally implemented knowledge elicitation and process tracing techniques such as observation, case studies, interviewing and concurrent verbal protocol (Cooke, 1999). These methods are generally employed in a multi-method approach to ensure that data collection is sensitive to the types of knowledge and processes used by both expert and novice decision makers (Popovic, Kraal, Blackler, & Chamorro-Koc, 2012; Sommer & Sommer, 1997). In addition to traditional methods, eye tracking technology has been reliably used to investigate decision making and expertise (e.g. Horstmann, Ahlgrim, & Göckner, 2009; Van Gog, Paas, & Van Merriënboer, 2005). In addition to expertise research, eye tracking has emerged in human computer interaction (HCI) studies as a result of its effectiveness for investigating usability (Poole & Ball, 2006). Due to the inextricable link between visual behaviour and cognition, the analysis of eye tracking data can be used to make inferences about specific qualities of visual interactions (Hayhoe & Ballard, 2005; Poole & Ball, 2006). For research investigating expertise and interface interactions in naturalistic contexts, eye tracking is particularly compelling as there is minimal likelihood of
the eye tracking technology interfering with other methods or influencing the participants’ cognitive processes (Glöckner & Herbold, 2011).

The most common eye movement data used to investigate cognitive processes are fixations and saccades (Bruneau, Sasse, & McCarthy, 2002). Fixations are points that the eye focuses on and represent cognitive processing, while saccades are the movements between fixations (Poole & Ball, 2006). In relation to cognitive processing, short fixations between saccades are generally associated with superficial, automatic processing and search, whereas long clustered fixations between saccades are associated with deeper processing and effortful analysis of information (Glöckner & Herbold, 2011; Poole & Ball, 2006). In addition to the individual characteristics of fixations and saccades, the sequences and arrangements of fixations and saccades, known as scanpaths, are used to infer characteristics of visual processing (Goldberg & Kotval, 1999). In HCI research, inefficient and extensive visual interactions are inferred by scanpaths with unfocussed fixation densities covering a large region of a display. When these scanpaths involve back and forward transitions and transitions that deviate greatly in direction (>90 degrees) it is likely that a user is experiencing uncertainty (Ehmke & Wilson, 2007) and a disconnection between what is expected and what is observed in reality (Goldberg & Kotval, 1999; Poole & Ball, 2006). On the other hand, effective and efficient visual interactions are inferred by unidirectional scanpaths with fixations targeted at smaller areas of a display (Goldberg & Kotval, 1999).

In the context of this research, scanpaths can be used to infer aspects about security screeners’ cognitive processes and the implications they have on interface interactions. For instance, when interactions are driven by prior experience, attention is guided to task critical information (Wolfe, 2010) and actions are performed effortlessly (Bastick, 1982), and thus correspond to efficient scanpaths. Conversely, knowledge limitations and inefficient interactions can be identified by the occurrence of scanpaths that infer inefficient and extensive visual behaviour (Ehmke & Wilson, 2007).

Method

Forty airport security screeners were observed while they performed x-ray screening of passenger carry-on baggage. Participants were selected to represent novice and expert experience levels. The novice experience group was comprised of eighteen security screeners with experience ranging from 1 to 12 months. The expert group was comprised of sixteen security screeners with experience ranging from 36 to 108 months. In addition to novice and expert categories, six security screeners were observed with experience between 12 and 36 months. Results from these six security screeners are not discussed in this paper. Participants were required to be able to perform screening without the aid of spectacles to ensure there was no interference with the eye tracking technology.

The experiment was performed in the field under normal task conditions at the departures security checkpoint of an International Airport. The duration of observations was between 20 and 30 minutes, comprised of two observation sessions with a break in between. Tobii eye tracking glasses were worn by participants during each observation. Participants were instructed to deliver concurrent verbal protocol, verbalising their decision making processes and actions during observations. Following observations, participants were required to take part in a short semi-structured interview with questions clarifying aspects about cognitive process, knowledge and interactions.
Analysis

Video and verbal data obtained from Tobii eye tracking glasses was coded using Noldus The Observer XT v10.5 (Noldus, 2013). A coding scheme which identifies key behaviours was developed from the video data collected from Tobii eye tracking glasses. The coding scheme identifies six behaviour categories which are search, examine, interface interaction, object interaction, screener interaction and downtime (Table 1).

Table 1: Behaviour categories from coding scheme

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Search</td>
<td>Visual interactions with stimuli displayed on the screen for the purpose of finding threat objects.</td>
</tr>
<tr>
<td>Examine</td>
<td>Visual interactions with stimuli displayed on the screen with the purpose of inspecting the nature and quality of objects or areas of interest.</td>
</tr>
<tr>
<td>Interface Interaction</td>
<td>Physical interactions with any function on the user interface, including application of zoom and IEFs, as well as interactions with the Threat Image Projection system.</td>
</tr>
<tr>
<td>Object Interaction</td>
<td>Visual and physical interaction with an object or piece of luggage located on the conveyor belt adjacent to the security screener.</td>
</tr>
<tr>
<td>Screener Interaction</td>
<td>Interactions with other security personnel, including requests for bags to be manually searched, requests for bags to be re-screened and asking for assistance.</td>
</tr>
<tr>
<td>Downtime</td>
<td>Activities that are performed while not actively screening. For example, waiting for the machine to resume or socialising.</td>
</tr>
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To further categorise behaviours, modifiers were applied to describe the types of knowledge and level of intuition used. Table 2 details the modifiers for each behaviour category with examples of the heuristics used to apply each modifier. Modifiers were developed from expertise and intuitive decision making literature, as well as inductively from data analysis during open coding. Open coding involves labelling concepts and categories during early stages of coding. As analysis progresses, coding themes are solidified in relation to the task and the aims of the experiment (Benaquisto, 2008). The heuristics used to apply modifiers have been derived from expertise literature, intuitive decision making literature and from eye tracking metrics used in current eye tracking research (Table 2).

Implementing open coding and coding heuristics is important for coding visual behaviour as eye tracking metrics can be interpreted in several ways. For example, high fixation frequency can denote interest in a subject due to the saliency of the object, or it could be interpreted as internal uncertainty (Poole & Ball, 2006). To aid the accurate application of modifiers and assist in clarifying cognitive process behind actions, concurrent verbal protocols were used. Furthermore, to ensure consistency of coding, data was cross coded by two researchers and an inter-rater reliability analysis was performed using the Kappa statistic. The result of the inter-rater reliability analysis was found to be Kappa = 0.69 (p<0.01). A Kappa value between 0.60 and 0.79 suggests substantial agreement between raters (Landis & Koch, 1977).
<table>
<thead>
<tr>
<th>Category</th>
<th>Modifier</th>
<th>Description</th>
<th>Example Heuristics</th>
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<tr>
<td>Knowledge</td>
<td>Perceptual Knowledge</td>
<td>Explicit knowledge about objects and concepts (de Jong, 1996). For example, knowledge of the appearance of objects used for the purpose of identification.</td>
<td>High fixation to saccade ratio (Goldberg &amp; Kotval, 1999) Dwell fixations (Goldberg &amp; Kotval, 1999; Poole &amp; Ball, 2006) Identification and evaluation of objects (verbalised, indicative of action) (Schwaninger et al., 2005)</td>
</tr>
<tr>
<td>Procedural</td>
<td>Knowledge</td>
<td>Knowledge of actions and procedures (de Jong, 1996; Popovic, 2003). Includes both implicit knowledge (e.g. search procedures) and explicit knowledge (e.g. interface features).</td>
<td>High saccade to fixation ratio (Goldberg &amp; Kotval, 1999) Fluid, focussed scanpath (Goldberg &amp; Kotval, 1999) Knowledge of interface functions Users explanation of procedures</td>
</tr>
<tr>
<td>Insufficient</td>
<td>Knowledge</td>
<td>Application of knowledge that results in incorrect action or misunderstanding of a situation.</td>
<td>Trial and error False positives Verbalisations such as ah..., what is that..., oh no… Asking for help</td>
</tr>
<tr>
<td>Uncertainty</td>
<td></td>
<td>Confusion, denial of information, irrational decision making, hesitation and indecision resulting from inadequate understanding of information and incommensurability (Hall, 2002).</td>
<td>Verbalisations indicating difficulty such as um…, I don’t know… Inefficient transition matrix (Ehmke &amp; Wilson, 2007; Goldberg &amp; Kotval, 1999) Clustered fixations (Poole &amp; Ball, 2006)</td>
</tr>
<tr>
<td>Intuitiveness</td>
<td>Intuitive</td>
<td>Rapid judgments enabled by prior knowledge and pattern matching (Bastick, 1982; Baylor, 2001; Salas, Rosen, &amp; DiazGranados, 2009).</td>
<td>Limited or no verbalisations (Bastick, 1982) Guided actions (Wolfe, 2010) Automatic and fluid actions (Bastick, 1982; Salas et al., 2009) Efficient scanpath (Goldberg &amp; Kotval, 1999)</td>
</tr>
<tr>
<td></td>
<td>Non-Intuitive</td>
<td>Analytic, deliberative processing of information and decision making (Bastick, 1982; Baylor, 2001)</td>
<td>Verbalisations (before and during actions) (Bastick, 1982) Analytic and isolated actions (Bastick, 1982) Inefficient scanpaths (Poole &amp; Ball, 2006)</td>
</tr>
<tr>
<td>Partially</td>
<td>Intuitive</td>
<td>Switching between intuitive and non-intuitive, surface level knowledge automated while more abstract concepts rely on conscious analysis (Baylor, 2001)</td>
<td>Limited verbalisations (during and following actions) (Bastick, 1982) Variable scanpath, some regressive saccades (Poole &amp; Ball, 2006) Mixed fixation to saccade ratio (Goldberg &amp; Kotval, 1999)</td>
</tr>
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</table>
Results
Analysed results focus on the knowledge types used by sixteen expert and eighteen novice security screeners during search, examination, interface interactions and interactions with security personnel. Results are expressed as percentages of the average time spent utilising knowledge types during each behaviour category.

Knowledge Types Accessed During Screening Activities
During search activities expert and novice security screeners were found to access perceptual and procedural knowledge (Figure 5). Both expert and novice security screeners were more likely to access procedural knowledge than perceptual knowledge during search activities. On average procedural knowledge comprised 86% of experts' and 83% of novices' overall search behaviour.

![Figure 5: Knowledge types used during expert and novice search behaviour](image)

Figure 5: Knowledge types used during expert and novice search behaviour

Expert and novice security screeners were found to access perceptual, procedural and insufficient knowledge during examination activities (Figure 6). On average perceptual knowledge was the most commonly accessed type of knowledge comprising 78% of experts' and 83% of novices' overall examination behaviour.

On average Novice security screeners were found to be more likely to access insufficient knowledge. Novices accessed insufficient knowledge during 10% of overall examination behaviour while expert security screeners accessed insufficient knowledge during 6% of overall examination behaviours. Novice security screeners were also found to be more likely to experience uncertainty during examination behaviour. On average uncertainty was experienced during 9% of overall examination behaviours by novice security screeners, while expert security screeners experienced 5% uncertainty during overall examination behaviour.
During interface interactions, expert and novice security screeners accessed perceptual, procedural, strategic and insufficient knowledge (Figure 7). Procedural knowledge was the most common knowledge type accessed during interface interactions. On average expert security screeners accessed procedural knowledge during 75% of overall interface interactions and novice security screeners accessed procedural knowledge during 67% of overall interface interactions.

Results show that novices were more likely to experience knowledge limitations, with 13% of overall interface interactions performed by novices involving insufficient knowledge. This is compared to expert security screeners who on average accessed insufficient knowledge during 5% of overall interface interactions (Figure 7). Experts were more likely to access strategic knowledge during interface interactions. On average experts used strategic knowledge during 19% of overall interface interactions while novices accessed strategic knowledge during 6% of overall interface interactions (Figure 7).
During interactions with other security personnel, expert and novice security screeners utilised perceptual, procedural, situational, strategic and insufficient knowledge (Figure 8). Results show that procedural knowledge was the most common type of knowledge accessed by both novice and expert security screeners. On average expert security screeners accessed procedural knowledge during 76% of overall screener interactions and novice security screeners accessed procedural knowledge during 64% of overall screener interactions.

Compared to procedural knowledge, the remaining knowledge types were found to constitute relatively small percentages of knowledge used during interactions with other security personnel (Figure 8). However, this is where the greatest differences between novice and expert security screeners were observed. Results show that experts were more likely to utilise strategic and situational knowledge while interacting with other security personnel. On average experts used strategic knowledge during 10% of overall interactions with other security personnel, compared to novices who did not access strategic knowledge. Similarly, experts were found to use situational knowledge during 9% of overall interactions with other security personnel, while novices used situational knowledge during only 3% of interactions.

Novice security screeners were more likely to access insufficient knowledge and experience uncertainty when compared to expert security screeners. Novice security screeners accessed insufficient knowledge during 14% of total interactions with other security personnel, while expert security screeners accessed insufficient knowledge during 2% of overall interactions with other security personnel. In terms of uncertainty, 19% of novice security screeners overall interactions with other security screening personnel contained uncertainty. Expert security screeners on the other hand experienced uncertainty during 7% of overall interactions with other security personnel.

Figure 8: Knowledge types used during expert and novice interactions with other security screeners
**Data Visualisations**

Visualisations of observation data show that the activities performed by security screeners can be broken into two main types of sequences: search and problem solving. Search sequences are comprised almost exclusively of search behaviour with other behaviours occasionally interspersed (Figure 9). Problem solving sequences on the other hand contain transitioning sequences of examination, interface and screener interactions, with very little search activity (Figure 9).

Figure 9: Visualisation of screening activity highlighting search and problem solving stages

Problem solving sequences can be resolved quickly, indicated by short sequences (Figure 10, box b), or they can be more intensive involving a number of shifts between different behaviours (Figure 10, box a). During problem solving sequences, screeners occasionally experience knowledge limitations which can cause uncertainty if not dealt with effectively.

Figure 10: Detail of problem solving sequences showing (a) long and (b) short interaction sequences

When experiencing uncertainty, security screeners were found to perform isolated and ineffective interactions with interface functions and visual stimuli causing interaction breakdowns and focus shifts. Focus shifts occur when a user performing an action is required to shift their focus from that action to focus on the tool in use (Bodker, 1996 in Popovic & Kraal, 2008). In the context of this research, focus shifts occur as the distraction of attention and reformulation of goals from one interaction to another. This research has
found that novice security screeners are more likely to encounter focus shifts and interaction breakdowns due to uncertainty and insufficient knowledge. In the novice security screener group 16 interaction breakdowns have been identified from 18 participants. Comparatively, within the expert security screener group, 5 interaction breakdowns have been identified from 16 participants. Of these 5 breakdowns experienced by experts, 1 was found to be the result of receiving incorrect information.

Figure 11 shows an example of an interaction breakdown experienced by a novice security screener. The problem solving phase began with the security screener examining an opaque area on the x-ray image at 155.00 seconds. Unable to identify the object, a black and white IEF is applied from 160.00 to 164.00. This is followed by another unsuccessful examination from 164.00 to 167.50 with verbal evidence indicating insufficient knowledge. From 167.50 to 170.50 the security screener applies 2x zoom and unsuccessfully examines the area between 170.50 and 175.00. Uncertain about the identity of the object, the security screener incorrectly identifies the object as a fictional threat image between 175.00 and 177.00, resulting in a short system delay. From 177.00 to 188.50 the screener performs a lengthy examination of the area indicating insufficient knowledge and uncertainty. Uncertainty and insufficient knowledge is further highlighted by the visual check of the physical bag between 188.50 and 190. The screener performs a final examination between 190.00 and 191.00 before requesting a physical search of the bag. This decision making process takes 52 seconds to resolve.

Figure 11: Visualisation of a novice security screener’s problem solving activity

The novice security screener’s problem solving process can be compared to Figure 12 which visualises an expert security screener’s problem solving in a similar event. Starting at 189.00 the expert security screener identifies and examines an opaque area. Unable to identify the objects the security screener applies 2x zoom from 191.00 to 195.00, immediately followed by application of a black and white IEF from 195.00 to 196.50. The area is examined in detail from 196.50 to 201.50. During this examination the security screener is unable to visually identify the object, however, it is determined that it may be suspicious. From 201.50 to
211.50 a searcher is called over and the security screener provides specific instructions for a manual search. This decision making process takes 22.5 seconds to resolve.

![Figure 12: Visualisation of an expert security screener's problem solving activity](image)

Instead of trial and error, the expert security screener demonstrates a highly organised and goal directed problem solving structure. Behaviours and interactions are planned and grouped, shifting focus only once between activities without needing to move backwards through their process and reformulate goals. The initial examination and interface interactions are engaged intuitively using procedural knowledge, while the more detailed examination phase is performed non-intuitively with focused attention. Recognising that their knowledge and the image presented by the interface are insufficient to identify the object, a manual search is immediately requested, circumventing any unnecessary interactions and avoiding uncertainty.

**Discussion**

The results from this research have found that the tasks performed by security screeners predominantly require access to knowledge of how and when to use procedures, as well as perceptual knowledge of objects and their appearance. Based on the primacy of procedural knowledge it is inferred that most tasks involve routine interactions with the interface and are performed with little difficulty. This is particularly evident during search tasks where no security screener experienced uncertainty.

In addition to routine situations security screeners were also found to encounter complex and unfamiliar problems that required more developed problem solving knowledge. During examinations, interface interactions and screener interactions, expert security screeners were more likely to access strategic knowledge, while novice security screeners were more likely to experience knowledge limitations and uncertainty. The differences observed between novice and expert security screeners suggest that experience plays an important role during problem solving activities. As a result of experience, security screeners develop
knowledge and strategies that better enable them to handle complex tasks and avoid uncertainty.

Although novice and expert security screeners were found to access the same types of knowledge, differences in their access to insufficient knowledge and strategic knowledge indicate that the quality of their knowledge base differs. These differences have visible effects on the way that security screeners interact with the tools used in the decision making context. According to de Jong, in addition to different types of knowledge, the knowledge base is further reduced to describe qualities of each knowledge type (de Jong, 1996). De Jong’s framework identifies depth, generality, automisation, modality and structure as the categories that can be used to describe the quality of each knowledge type. As higher quality of knowledge is gained, knowledge becomes increasingly integrated. This integrated knowledge is known as problem scheme knowledge and refers to high quality and interlinked situational, procedural and conceptual knowledge (Friege & Lund, 2006). Experts are considered to have greater access to problem scheme knowledge than novices. When confronted by a situation, problem scheme knowledge is used to rapidly identify patterns and recall specific and integrated actions suitable to the situation (Salas et al., 2009). Novices on the other hand rely less on problem scheme knowledge, using non-specific and unintegrated declarative knowledge. At a low level this knowledge is isolated and superficial. Problems are solved through interpretative application of knowledge which involves dividing solutions into several individual steps where each individual rule has to be checked to see if it is useful (Friege & Lund, 2006).

The distinction between different qualities of knowledge is illustrated in the data visualisations from this research. The problem solving process of the novice security screener (Figure 11) shows an interpretive application of superficial knowledge; interactions with interface functions are performed by trial and error and disjointed from examination activity. The example of expert problem solving (Figure 12) on the other hand demonstrates integrated problem scheme knowledge. Interface interactions are grouped and performed intuitively. A clear goal is established facilitating the integration of interactions into a focused and fluid sequence. These results show that access to different qualities and structure of knowledge has implications for the way that interfaces and their functions are used in the security screening context.

**Implications for Interface Design**

Improving interface interactions during problem solving could provide benefits for both inexperienced and experienced security screeners through facilitating more efficient problem solving and supporting the transition from novice to expert.

Firstly, interface design should support efficient sequential use of functions in order to minimise focus shifts and allow the screener to focus on important visual interactions. Efficient access to interface functions will encourage higher use rate of functions, and the subsequent development of problem schemas. The more accessible interface functions are, the more experience with the interface is gained. As experience is gained problem schemas become refined and the more likely they will be accessed (Mandler, 1985). This is desirable as it will improve the efficiency of interactions and their integration into effective problem solving sequences.

Secondly, the design of interface functions should be relevant and adaptive to the problem context and the skills of the user. During unfamiliar events users often do not have knowledge of established problem solving methods and are required to improvise and are
susceptible to making errors (Vicente & Rasmussen, 1992). This scenario has implications for interface design as the errors that occur during unfamiliar events cannot simply be overcome by improving human factors elements such as the layout and design of controls. Instead, these difficulties must be understood and addressed in terms of the cognitive factors that influence interactions (Vicente & Rasmussen, 1992). For interfaces to support human performance in unfamiliar environments interface design should consider both the context and the user. Vicente and Rasmussen (1992) suggests that during situations that are unfamiliar to users, interfaces should be designed to capture the state of complexity in the context and visualise information and interface functions in a way that supports the skill level of users. An example of this is the use of adaptive interfaces. In the airport security screening context, adaptive interfaces could identify difficult image characteristics and visualise relevant functions to novices during unfamiliar situations. As experience is gained the adaptive interface design could identify individual strategies used frequently by security screeners and integrate these into interface functions to improve efficiency.

Although this research focussed on airport security screening, it is believed that the methods and findings are transferrable to interface design in other domains. By visualising the activities and cognitive processes of users, insights can be gained about interaction sequences used to solve problems and the difficulties that are encountered during certain situations. The observation of interaction breakdowns indicate points of interaction and specific contextual states where users would benefit from more information or improved interface functionality. Although this needs to be tested in other domains, it is the belief of the authors that the methodology and findings presented in this paper could be used to improve the design of artefacts and interfaces used in other domains. It is particularly relevant for complex activity contexts where rapid transition from novice to expert is desirable, for example, medical domains that rely on imaging technology. In addition to complex activity contexts, these methods could be applied to interface design in domains that target user groups with varying skill levels, for example the design of check-out interfaces in retail.

**Conclusion**

Previous research investigating expertise in the security screening context has focussed on visual knowledge and threat identification (e.g. Schwaninger et al., 2005). This paper expands on previous research, finding that type and quality of knowledge also play a critical role during x-ray screening and affect the structure and effectiveness of interface interactions during problem solving. As a result of greater experience, expert security screeners are able to effectively utilise interface functions during strategic and focussed problem solving. Without access to the same quality of knowledge, novice security screeners are more likely to experience uncertainty and difficulties during problem solving. Due to this, novice security screeners are more likely to use interface functions in trial and error type strategies resulting in inefficient problem solving and interaction breakdowns.

Applying these findings to interface design has the potential to improve the user experience and effectiveness of the systems used by security screeners. Two recommendations are proposed which address the differences in knowledge base and knowledge requirements of expert and novice security screeners. It is suggested that interfaces (i.) should encourage efficient sequential application of functions, and (ii.) should be adaptive to the problem context and the skills of the user. It is the aim of these recommendations to support the knowledge and skills for both novice and expert security screeners during problem solving as well as facilitate knowledge development and the transition from novice to expert.
The methods used for visualising data in this research enable relationships between knowledge, activities and interactions to be seen. These methods are significant as they illustrate how knowledge and cognitive factors influence user interactions with systems and interfaces. Although this paper focused on airport security screening, it is believed that the methods and findings discussed in this paper are transferable to interface design in other domains such as medical imaging and retail.

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References


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**Vesna Popovic**

Vesna Popovic is a Professor in Industrial Design at Queensland University of Technology, Brisbane, Australia. She has made an international contribution to product design research where she has integrated knowledge from other related areas and applied to the artifact design (e.g. human factors/ergonomics, product usability, design and cognition, expertise and experience, design computing or applied design research) in order to support and construct design applications. Vesna has been leading Human Systems Program in the ARC Linkage project ‘Airports of the Future’ where she has been focusing on peoples’s experiences at an airport terminal. She was a joint recipient of the 2011 Engineers of Australia Queensland award for R&D for a pilot study “Airports of the Future”. Vesna has been a founder of People and Systems Lab research at QUT. The impacts of Vesna’s research lies in the cross-fertilisation of knowledge across humanities and technologies to design humanised artifacts/ systems by facilitating the understanding of diverse expertise.
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