



Using Cognitive Psychology Research to Inform Professional Visual Search Operations



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Visual search—locating target(s) among distractors—is a common practice that can range in difficulty from trivially easy to nearly impossible. Professional searches (e.g., airport security, radiology) typically are among the most complicated and challenging tasks, and also often among the most important. The current discussion examines empirical findings in the cognitive psychology literature that contribute to professional search operations, with an emphasis on airport security screening. Primarily, this article focuses on multiple ways to achieve optimal proficiency in security screenings, including personnel selection, training, and continuing assessments. Some of the existing best practices include using orthogonal visual search tasks as predictors of future performance (for selection), item-specific training (for expertise development), and annual competency tests (for continuing assessment). Future research opportunities are discussed, with one especially notable area for future research involving how individuals can potentially develop optimal scanning behaviors for professional search.

Keywords: Professional search, Visual search, Airport security, Personnel selection, Training

General Audience Summary

Many professions (e.g., radiology, airport security) demand highly accurate and efficient visual search, which is the ability to locate target items among distractors. For example, radiologists search radiograph X-rays for cancerous tumors, airport security screeners search luggage X-rays for guns, and Marines search roadsides for improvised explosives. Each professional instance provides its own set of challenging circumstances, yet there are certain common elements and best practices that apply broadly across most professional tasks that require visual search. The current discussion addresses the challenges of selecting and developing proficient visual search by covering three core topics, with a focus on airport security screening as a primary example. First, there is the challenge of selecting the best personnel. Some individual differences link various other cognitive abilities to visual search, yet one of the best demonstrated individual differences thus far appears to be visual search performance on another visual search task, even if the stimuli are unrelated. Second, there is the challenge of training novice individuals into professional visual searchers. The current discussion

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addresses several important factors in the training process, including the process of learning to identify critical targets, learning to operate key equipment, and developing optimal scanning behaviors. Recent cognitive studies have advanced the general understanding of the development from novice to expert, yet significant additional research opportunities remain, especially in developing better scanning behaviors. Third, there are continuing performance assessments that are essential to maintaining skill sets throughout a career. Annual competency tests are combined with on-the-job feedback to maintain performance standards within many professional fields, although emerging big-data opportunities can enhance the existing training opportunities. Taken together, this discussion covers the existing cognitive science research and future research opportunities with the potential to improve professional visual search capabilities.

Visual search—the act of finding targets among distractors—is a fundamental ability central to many professional fields. Airport security screeners scan X-ray images of luggage for prohibited items, radiologists scan radiographs for various health issues, Marines search for improvised explosive devices (IEDs) along roadsides, and so on. Each professional scenario brings new challenges and has aspects unique to the specific field. For example, lifeguards may search for signs of motion, or lack thereof, while surveying the water to identify possible drowning victims (e.g., [Lanagan-Leitzel, Skow, & Moore, 2015](#)), whereas motion plays a very different role for airport security screeners searching luggage (e.g., [Biggs & Mitroff, 2015](#); but see also [Mendes, Schwaninger, & Michel, 2013](#)). Whatever the specific situation, however, professional searches are often critically important as they can have life-or-death consequences. Radiologists missing tumors can mean life-threatening cancer goes undetected, and security screeners missing bombs could threaten air travel. The potentially severe consequences of poor performance make it essential that the personnel are highly competent and well-trained professional searchers.

The goal of the current discussion is to describe the challenges involved when selecting and evaluating professional searchers with respect to developing and maintaining proficient visual search abilities in a professional environment. As such, we will focus on three primary areas: (a) selecting individuals with the optimal predispositions to professional visual search tasks, (b) training individuals for a professional visual search, and (c) maintaining proficiency through continuing competency assessments. Our focus will be on the contributions of cognitive psychology to the greater understanding of professional visual search with a particular emphasis on airport security screening. The discussion will begin with a brief description of the cognitive challenges in professional visual search with the majority of examples coming from airport security.

Differences Between Professional Search Tasks and Everyday Search Tasks

Many everyday tasks involve visual search (e.g., people look for their shoes in the morning, a particular message in their email inbox, and their kids at the playground). Even so, such everyday searches are often substantially less complex and less critical than searches conducted by professionals ([Biggs & Mitroff, 2015](#); [Hodgetts, Vachon, Chamberland, & Tremblay, 2017](#)). In the example of people searching for their shoes, searchers have

knowledge about what the shoes look like, where they usually are, that there should be two shoes, and a wealth of other contextual information that reduces task complexity. Moreover, there are widely variable time pressures for people to find their shoes, and a high likelihood of success. In contrast, an airport security officer faces great time pressures and many potential obstacles to success: not knowing if there is a prohibited item packed in a particular bag, where the item would be, what the item is, and if additional items might also be present.

While there are many ways to categorically divide everyday and professional searches, one overarching difference is that professional searches often involve a higher level of uncertainty. Whereas everyday searches can usually be titrated down to the search for a specific target in a specific scenario, professional searches are often more noisy and ambiguous. This difference highlights a potential disconnect between cognitive psychology research and real-world visual search; specifically, a core concept in the cognitive psychology literature suggests that visual search can be driven by the formation and use of “target templates”—mental representations searchers use to distinguish target items from distractors during search ([Vickery, King, & Jiang, 2005](#)). These representations can consist of detailed visual information (e.g., [Vickery et al., 2005](#)) or categorical information ([Yang & Zelinsky, 2009](#)).

The underlying and well-replicated concept is that greater specificity in the target template produces better visual search speed and accuracy (e.g., [Bravo and Farid, 2009, 2012](#); [Malcolm & Henderson, 2009](#); [Schmidt & Zelinsky, 2009](#)). For example, a searcher will find a target faster and more accurately if they search for a blue square versus any blue shape. However, imprecise target templates are an unfortunate and almost unavoidable demand for many professional search tasks. Security officers will have a good understanding of potential prohibited items, but the list is often extremely long (guns, knives, bombs, etc.) and the searcher does not know what items (or what exemplars of those items) will be present on any given search. Unlike two potential targets in a laboratory visual search task, two prohibited items at a checkpoint are not given the same consideration. For example, missing a screwdriver could be problematic, but missing an IED could be catastrophic. This distinction creates a type of hierarchy among items, where guns, knives, and IEDs are prioritized over other less threatening targets such as pliers or a hammer.

As such, the main target categories are relatively limited, yet each target type includes an exceptionally long list of individual exemplars. The target categories are further complicated by

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