SMOKE: Effective Cognitive and Field Training for IED Detection

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Learning Objectives

After reading this paper, the reader should be able to:

1. Demonstrate understanding of the difficulties and principles involved in successful IED search and detection.
2. Demonstrate understanding of the importance of prior frameworks for understanding, and of explicit, feature-intensive, cognitively-based training as foundations for successful IED search and detection.
3. Understand that in a controlled experiment, the ability of respondents to detect IED’s was significantly and substantially enhanced by such integrated training.
4. Discuss the five types of errors typical of less-successful IED search and detection.
5. Understand the importance of the incorporation of field exercises in the development of successful training for IED search and detection.
Abstract

In an earlier article, we introduced the SMOKE system of cognitively-based training for improvised explosive device (IED) detection. SMOKE (based on the acronym for the five identified types of IED search error) literally doubled the detection performance of trainees in a single session, and defeated three of the five error types. As suggested in our earlier work, the present research incorporated a simple field exercise, also based in cognitive principles, to enhance the SMOKE system. This integrated approach defeated all five error types. This research demonstrates the importance of cognitive principles in the development of training, and provides a ready-for-deployment system of training for immediate use in law enforcement applications, and in corporate, commercial, transportation, and educational security environments.

**Keywords:** Improvised Explosive Device Detection, Explosive Ordinance Disposal, SMOKE System, Law Enforcement Training, Security Training
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SMOKE: Effective Cognitive and Field Training for IED Detection

As warfare in Western Asia enters its second decade, the detection of improvised explosive devices (IED’s) has become increasingly important, both in domestic applications and abroad. Military approaches to IED interdiction have incurred substantial criticism, both in terms of progress and performance, even at the Congressional level (McClatchy Newspapers, 2011). Also, military advances in IED interdiction are not generally available to law enforcement, or to those entrusted with the security of corporate, commercial, transportation, and educational environments. The potential for IED threats in such environments is widely anticipated to have ongoing and increased importance in the future (e.g., Cameron, 2008; Johnson, 2011). This increase is, of course, expected to result in largely from the activities of genuine terrorists. However, it is important to realize that “copycat” offenders may readily become impressed with the power and notoriety of these weapons, and may use them in a variety of criminal venues, ranging from homicide and gang warfare to the robbery of such hardened targets as banks and armored cars. Thus, for domestic law enforcement and security applications, there is a strong and growing need for effective, economical training in the detection of IEDs.

At present, IED search-and-detection training may involve practice in the recognition of various types of IEDs, and field training in which trainees are exposed to practice environments containing mock explosive devices. As discussed in previous work (Sharps et al., 2010; also see Sharps, 2010), these types of training are laudable and important in the development of hazard detection skills. However, they generally lack important cognitive components. Specifically, these are prior frameworks for search
methods; explicit connections between the skills employed and their rationales; and the use of specific, feature-intensive training to form smooth, coordinated search methods in the field (Sharps, 2010; also see Bransford and Johnson 1972, 1973; Haviland & Clark, 1975). As will be seen, these cognitive components, based on sound principles of cognitive science, are crucial for the development of the most effective forms of anti-IED training.

Initial Considerations

Research in our laboratory, especially as concerned with eyewitness cognition, has demonstrated the need for the application of cognitively-based principles in visual search training (e.g., Sharps, Barber, Stahl, & Villegas, 2003; Villegas, Sharps, Satterthwaite, & Chisholm, 2005; Sharps, Hess, Casner, Ranes, & Jones, 2007; Sharps & Hess, 2008; Sharps, Janigian, Hess, & Hayward, 2009). The need for these principles assumes special significance in the search for IEDs. In our studies, many respondents looked directly at an explicit source of hazard, such as a hand grenade, or at an implicit potential source of hazard, such as a military ammunition box situated among street clutter, without actually noticing these hazards (Hess & Sharps, 2006, April; Sharps et al., 2007). The same effects may be observed in law enforcement training; even veteran officer trainees, when confronted with the need to move quickly to the scene of a mock violent crime, may completely ignore mock IEDs in plain sight, even to the degree of kicking them out of the way without noticing them (Sharps et al., 2010).

These considerations were important in the development of the present research, which was concerned specifically with the improvement of IED search and detection in realistic contexts.
The Cognitive Basis of SMOKE

Training for IED detection involves the enhancement of cognitive skills. As noted above, however, much of the training currently available for domestic law enforcement and civilian operations lacks grounding in the cognitive principles most likely to ensure success. The most important principles, as mentioned above, are detailed as follows (Sharps, 2010):

1. Training should provide a prior framework for understanding. The specific purposes, utility, and scope for which a given evolution is appropriate should be made clear to all trainees prior to exercises in the given skills (see Bransford and Johnson, 1972, 1973). This “front loading” is essential for training success.

2. Training should be explicit. Trainees should not have to imply or infer the circumstances under which the training may be useful. The specific skills, and the specific circumstances under which they may be applied, should be explicitly clear to trainees prior to practice exercises (see Haviland and Clark, 1975).

3. Training should initially be feature-intensive in nature. Trainers should initially provide a step-by-step breakdown of the skills involved in any training evolution. They should provide explicit guidance concerning each feature of the skill set in question, together with its use in responding to the reasonable spectrum of eventuality which officers may encounter in the field. The skills involved should be explicitly understood by trainees, as a prior framework for understanding, prior to practice exercises (see Sharps, 2003, 2010).
With a prior, explicit, feature-intensive framework in place, practice exercises and subsequent performance will generally be enhanced in effectiveness, ultimately resulting in the smooth, “gestalt” sets of responses necessary for rapid response in the field (Sharps, 2010).

In a recent paper (Sharps et al., 2010), we presented the initial version of SMOKE, a system of training for IED detection based in these principles. Training for IED detection must address several specific issues, discussed in full in that paper. In summary, these are as follows:

1. Human beings tend to focus on the core of a given situation, at the expense of the periphery of the given scene where IEDs may be placed (e.g., Grossman & Christensen, 2004). Therefore, a number of exercises, using a variety of mock IEDs, were included to develop the habit of peripheral search.

2. These exercises involved violent crime scenes, developed in consultation with law enforcement experts, and incorporating armed and unarmed perpetrators of both sexes. This developed the habit of central and peripheral search even in the presence of potentially distracting “core,” or central, activity.

3. Trainees were exposed to a variety of IED types, of different levels of visual salience, in different central and peripheral locations.

4. IEDs may be disguised, or they may be placed or constructed in such a way that they present an innocuous or ambiguous visual picture to the observer. In other words, an IED may present itself in such a way that the major clue to its existence is its inappropriateness to the local environment. This may be true of a length of pipe which should simply not be where it is, or of a metal container which becomes visually lost among other clutter, but which is definitely out of place. This problem assumes special significance when a disguised or innocuous object is
placed on the periphery of a given action. Even when such an object is directly observed, it may be completely misinterpreted. Therefore, exercises explicitly directed trainees to evaluate the appropriateness of objects for their surroundings.

5. Trainees were also explicitly shown how to evaluate the prospect that an object might be an IED, based on the relative probability of that type of object being in the given scene.

This training was front-loaded and explicit, intended to form a prior framework for understanding (Bransford & Johnson, 1972, 1973). Finally, the training was based in feature-intensive understanding both of the training protocol and of the types of scenes to which it was to be applied (Sharps, 2003, 2010).

The system was extremely effective. Trainees with no prior relevant experience exhibited, on average, a doubling of success in detecting a well-concealed IED, and took half as much time to detect an IED placed in plain sight in a moderately-cluttered environment, when compared with a control sample (Sharps et al., 2010).

Errors in IED Search

The acronym SMOKE is based on the five types of errors which were observed to occur in an IED search, specifically errors of Search, Movement, Observation, failure to Keep searching, and errors of Evaluation. These are described as follows (quoted from Sharps et al., 2010):

1. Errors of SEARCH. For this error type, respondents focused on only one part of the room, or only on one plane, failing to look up or down. An interesting finding was that some respondents focused on only one side of the room, failing to notice anything on the other side. In short, respondents frequently took part of the room as their core search area, and failed to examine items on the periphery of the given area.
2. Errors of MOVEMENT. There was a tendency on the part of some subjects to remain in one place in the room, frequently at the door. From such a perspective, many areas of the room, behind things and under tables, were completely invisible to them; there was frequently no tendency to move about the room in an effort to take different necessary visual perspectives.

3. Errors of OBSERVATION. In these errors, respondents looked directly at a given IED but did not report it, moving on to look at other things. In some cases, the same error was made repeatedly with a given IED. Whether these respondents mistook the given IED for something else, or simply did not see it in some sense, is unknown at this time. However, just as a person can look at a power screwdriver and see a handgun (Sharps & Hess, 2008), respondents who made errors of Observation looked at a large, silvery pipe bomb, with a timer and a battery pack clearly in view, and saw nothing dangerous at all.

4. Failures to KEEP SEARCHING. In these instances, respondents decided they had found everything there was to find. An innocuous object would be identified as an IED, and the individual would report to the experimenter that he or she was finished, even in the presence of additional secondary devices which remained undetected.

5. Errors of EVALUATION. These occurred when respondents identified innocuous objects as IEDs. Such objects included a briefcase; a laptop computer; an electronic amplifier for physiological experiments (the room used for the field exercise was a laboratory chamber); a small pillow; and a wooden box. Some of these objects were plausible disguises for IEDs; others were not, ranging from the implausible to the absurd. What is important about these errors, however, is that they occurred when the actual mock IED was in plain sight.
The five letters of this acronym form a group at an optimal level of memory organization (Mandler, 2011). Thus, the acronym forms an excellent mnemonic device on which a front-loaded prior framework for training in IED detection may be based.

The original version of SMOKE, consisting solely of Powerpoint-based training (summarized above and described fully elsewhere; Sharps et al., 2010), doubled the performance of trainees, as discussed above. However, only three of the five error types (Search, Observation, and failures to Keep Searching) were defeated by the original training. It was suggested in that work that integration of the PowerPoint training with an appropriate field exercise would increase the effectiveness of the system, potentially defeating all five error types. The multimodal nature of field training, requiring movement through an appropriate environment and the evaluation of a variety of items which might or might not prove to be IEDs, was anticipated to improve performance, especially with reference to the two types of errors remaining (errors of Movement and of Evaluation). This is the subject of the present article: an integrated, multimodal version of SMOKE, combining cognitive principles with a relevant field exercise to provide optimal training for IED detection.

Method

Participants

Twenty-eight women (mean age 18.63 years, SD = 1.04) and twenty-four men (mean age 19.37 years, SD = 1.17) were recruited for course credit from university psychology classes. These participants were of similar age to law enforcement cadets and many beginning applicants for security employment; additional research will be
needed to ascertain the degree to which the observed effects generalize to older or more experienced populations.

Materials

The importance of IEDs, and of effective search for such devices, was presented to respondents. Following this, for the experimental group, the SMOKE PowerPoint was employed, consisting of 50 slides. Redundancies derived from the experimental nature of the initial SMOKE program were deleted for this final version. Ten “preliminary” slides were shown, describing the SMOKE error types, and depicting IEDs in situations incorporating victims and armed and unarmed assailants. These slides provided a prior, explicit framework for the spectrum of situations in which IEDs might be encountered.

A series of eight slides, depicting an individual presenting IE’s of various types, followed the ten preliminary slides. This series of eight provided a feature-intensive introduction to the spectrum of types of IEDs which might be observed in field situations.

These were followed by twenty-four “content” slides, depicting various IED types in various peripheral and central locations, in a scene incorporating an armed or unarmed perpetrator (of either sex) “threatening” a potential “victim.” As in previous work (Sharps et al., 2010), each content slide depicted a potentially violent street situation, which took place in a gravel driveway with garbage cans and street clutter in the picture. In each scene, a male or female assailant aimed a handgun at a female victim, or, unarmed, pointed at her in an identical posture. This type of scene has been extensively used in our earlier work on memory, cognition, and eyewitness identification (e.g., Sharps, Hess, Casner, Ranes, & Jones, 2007; Sharps & Hess, 2008; Sharps, Janigian, Hess, & Hayward, 2009; also see Sharps, 2010). In the present study, however, the
scenes were augmented by the presence of the mock IEDs. The scenes varied in terms of the size and color of the IEDs (and hence, the visual salience of the given devices); the placement of those IEDs at different peripheral and central locations; and the degree to which a potential IED was disguised or not (e.g., an unadorned grenade versus a new backpack which, while placed in an odd location, did not give other visual evidence of having been an IED). Finally, three of the scenes incorporated multiple IEDs, to demonstrate the need to “keep searching” for secondary devices in a given environment, even after an initial device is detected and identified.

The types of IEDs employed included a grenade; a single-pipe bomb; a gasoline can rigged with a mock detonator; military ammunition cans; a battered briefcase; and a new backpack. Both male and female “assailants” were employed because subjects in previous experiments on eyewitness identification (e.g., Sharps et al., 2007, 2009) have evinced surprise at seeing a female assailant. These slides provided practice in IED search in the presence of potentially distracting “core” scene elements such as the presence of a female assailant, rather than of the generally anticipated male.

It should be noted here that in the case of an armed assailant, that particular “core scene element” could prove to be as hazardous as an IED. Therefore, and especially in the case of law enforcement trainees, it is vitally important simultaneously to promote the ability to assess and to deal with core threats (see Sharps & Hess, 2008, for related commentary). There appears to be nothing inherent in SMOKE training that would detract from core interpretation. In fact, we might anticipate some generalization of SMOKE training to other aspects of scene interpretation, potentially improving core response (see Sharps, 2010 on prior cognitive frameworks for the optimization of
training). However, the optimal incorporation of SMOKE into various types of training should be the subject of further research across potential trainee populations, especially those involved in active law enforcement.

The twenty-four content scenes were followed by eight slides again explicitly stating and summarizing the SMOKE error types, to enhance recency effects in recall of the essential principles (e.g., Crowder, 1976).

**Procedures**

As in the earlier work (Sharps et al., 2010), these materials were presented to members of the “training,” or experimental, group, together with an accompanying script, read by a male experimenter. As discussed above, this script first introduced the importance of IED issues. Then, as each slide was presented, the lesson of that particular slide was explicitly discussed. These lessons included the following:

1. The fact that IEDs may be obvious or difficult to see, either because they are hidden or because they form good contours with their immediate environment.
2. The need to search peripheral as well as central locations in any given scene.
3. The need to conduct and continue such search even if surprised by a factor such as a female assailant.
4. The need to continue search even after a given IED is discovered.

This SMOKE PowerPoint presentation was provided for the experimental group. The control group, in contrast, was merely given the initial information on the importance of IED issues, as discussed above.

*Field Exercise.* A major goal of the present study was to evaluate the effectiveness of SMOKE as an integrated system, incorporating the PowerPoint training
with a field exercise. Therefore, for the training or experimental group, the SMOKE PowerPoint presentation was followed by such an exercise.

In this field exercise, three mock-IEDs of different types were placed in a moderately cluttered office. Each device was placed so that it was not visible from the trainee’s initial position at the door of the room. Each trainee was explicitly shown the need to move through the room to observe the first of the three IEDs. Then each trainee was instructed to make a circuit through the room, with explicit instructions to look low, middle, and high. Each trainee was guided, as needed, to a search pattern which would enable him or her to find each of the two additional IEDs without further direct guidance on the part of the instructor. Thus, this exercise provided a prior framework for understanding the explicit, feature-intensive characteristics of search which would ultimately lead to success.

**Dependent variables: Measurement of success of training** (identical with earlier evaluation method; Sharps et al., 2010). To evaluate the results of this training, a “field search” situation was created in a moderately cluttered, eight-by-twelve foot laboratory room. This room contained three chairs, a large rolling tool chest, several computers and a printer, some electronic instruments, and a scattering of books, papers, and notebooks on a counter and on two desks. A mock IED was placed between two computer monitors, in plain sight, on one of the counters. This IED (the “simple” device, because it was in plain sight from the respondent’s point of entry to the room) was a pipe bomb, consisting of three metal pipes bundled together with a timer, power pack, and appropriate wiring. The device was fourteen inches long and approximately five inches in diameter. Two other devices were also placed. One was a single-pipe bomb with
power source and timer, placed in a position between two computer elements on a table at average waist height; this device required respondent movement for detection (hence its designation of “moderate” difficulty). The third device was a fragmentation grenade with power source and timer, secreted at floor level in the relative darkness of shadow, and contoured with reference to furniture features; this was the “difficult” device, requiring movement and perceptual differentiation from innocuous features of the environment.

Participants in both the control and training conditions were simply told to enter the room and to search for hazardous devices. On seeing such a device, if any, they were told to point directly at it and say the word “bomb.” Their responses were clocked on a Lafayette Instruments precision timer.

**Results**

**Time to Detection for Each IED**

The effect of training on time to detection for the three devices was significant, multivariate $F (3, 28) = 102.85, p < .001$. For the “simple” device, control respondents averaged 37.48 seconds to detection, whereas trainees averaged 26.13 seconds. For the “moderate” device, control respondents averaged 48.41 seconds, and trainees averaged 20.61 seconds. For the “difficult” device, control respondents averaged 89.09 seconds, whereas trainees averaged 34.85 seconds. Univariate post-hoc tests revealed significant advantage for the training group over the control group, respectively $F (1, 45) = 7.23, p = .010$; $F (1, 44) = 31.43, p < .001$; and $F (1, 31) = 32.85, p < .001$. Thus the SMOKE training group was significantly faster than the control group in finding all three devices; across the three devices, the SMOKE system resulted in an average speed of detection
approximately double that of the control group, with the greater advantage being observed with increased difficulty of device detection.

**Probability of Detection for Each IED**

The effect of training on the probability of locating each IED was significant for each IED type. Twenty-one of the control respondents found the simple device, whereas all 26 of the training group found it, $\chi^2 (1) = 4.51, p = .034$. Twenty of the control respondents found the moderate device, whereas, again, all 26 of the training respondents found it, $\chi^2 (1) = 5.76, p = .016$. Only eight of the control respondents found the difficult device, whereas 25—all but one—of the training group found it, $\chi^2 (1) = 22.97, p < .001$. Thus the SMOKE group was significantly more successful in finding all three devices; whereas the control group yielded a success rate of only 62.82% across the three devices (finding the given device in a total of 49 out of 78 opportunities), the SMOKE group was successful in all but a single IED discovery, a success rate (77/78) of 98.72%.

**Defeat of Errors by Type**

As discussed above, five types of errors occur in IED search: errors of search, movement, observation, failures to keep looking, and evaluation (thus, the acronym SMOKE). The training group was superior to the control group in defeating all five types of error, multivariate $F (5, 45) = 25.29, p < .001$. Means, standard deviations, and univariate $F$ tests are provided for all five error types in Table 1. All five error types were significantly and very substantially diminished by the training.

Thus, the integrated SMOKE training, with field exercise, significantly and substantially reduced the time needed to find all three levels of IEDs: simple, moderate, and difficult. SMOKE also, significantly and substantially, increased the probability of
finding all three levels of IEDs. SMOKE training further, significantly, and substantially, decreased all five SMOKE error types, including the error of Evaluation and failure to Keep Looking previously undefeated by the PowerPoint training alone.

Discussion

Previous research on the PowerPoint component of SMOKE produced effects similar to those observed here, with the exceptions that errors of Movement and Evaluation were not defeated by the PowerPoint alone in that earlier work, and all five error types were defeated by the present integrated version of SMOKE. This was unsurprising. PowerPoint SMOKE training alone, even though front-loaded, explicit, and feature-intensive in nature, was never intended to replace field training. Rather, it was presented as a powerful adjunct and framework for field training. The present findings clearly underscore and demonstrate the accuracy of this perspective: the incorporation of a simple field training evolution into SMOKE resulted in the defeat of all five error types.

These results demonstrated that those trained in the cognitive skills engendered by SMOKE must also have additional, integrated field training, in which they search realistic mock environments. Such integrated field training operates to foster the “movement” skills needed for successful search, and also to fine-tune the skills acquired through SMOKE for the evaluation of real-world environments. The incorporation of field training, as discussed in earlier work (Sharps et al., 2010), optimizes both the primacy and recency effects (see Baddeley, 1990; Baddeley & Hitch, 1993; Crowder, 1976; also see Sharps, Price, & Bence, 1996) for optimal memory and retention of the training.
It should be noted that the impressive results of the combined SMOKE system were directly based in the principles of modern cognitive psychology. This fact strongly underscores the importance of cognitive principles in the development of training for the modern world of tactical exigency. In view of the enhanced operational tempo of modern law enforcement and security environments, the enormous advantage conferred on training regimens by the proper use of modern cognitive principles can hardly be overestimated. In the present research, these principles derived from the “trinity” of modern cognitive training: first, the development of prior cognitive frameworks; second, explicit processing within those frameworks; and third, feature-intensive understanding, both of the specific tasks to be performed and of the environments within which those tasks must be undertaken and applied (Sharps, 2010).

Additional research will help to determine the environments and populations for which SMOKE and similar methods are of the greatest utility. However, as discussed above, the simple facts remain that the danger of IED attacks, both domestic and foreign, remains high and will probably increase through time. More traditional training approaches to the problem have been acknowledged to be less than effective, and coherent, economical, effective programs of training for IED detection are generally relatively unavailable to non-military law enforcement and security forces. This unfortunate fact embraces realms of security operations in environments as disparate as educational, commercial, industrial, and transportation facilities. It is very likely that the incidence of terrorism, obviously including the deployment of IEDs, will increase substantially, on the domestic front, in coming years (e.g., Johnson, 2011). The integrated SMOKE approach now stands as a cognitively-based training
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system entirely appropriate to these environments, and which is now ready for
deployment at relatively minimal expense in terms of time and financial resources. It is
strongly recommended that this approach be applied in the immediate future, with proper
research at each stage of development, for the protection of officers, security personnel,
and the general population alike, and that further research be conducted on the
application of similar cognitively-based techniques to other areas of increasing tactical
and security importance. This type of approach may ultimately provide the most
successful enhancement of officer survivability, professional effectiveness, and best-practice abilities to protect the general population in an increasingly risky world.
References


Table 1
Mean Numbers of Errors/Standard Deviation by Type, with Univariate Significance

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Control Group</th>
<th>Training Group</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search</td>
<td>6.96/3.63</td>
<td>1.15/1.64</td>
<td>$F(1,49) = 54.77, p &lt; .001$</td>
</tr>
<tr>
<td>Movement</td>
<td>5.48/4.20</td>
<td>0.35/1.06</td>
<td>$F(1,49) = 36.41, p &lt; .001$</td>
</tr>
<tr>
<td>Observation</td>
<td>3.32/0.90</td>
<td>0.54/0.90</td>
<td>$F(1,49) = 47.53, p &lt; .001$</td>
</tr>
<tr>
<td>Keep Looking</td>
<td>1.72/1.34</td>
<td>0.31/0.68</td>
<td>$F(1,49) = 22.82, p &lt; .001$</td>
</tr>
<tr>
<td>Evaluation</td>
<td>3.04/3.32</td>
<td>0.89/1.47</td>
<td>$F(1,49) = 07.55, p = .008$</td>
</tr>
</tbody>
</table>
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