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Canine human scent identifications with post-blast debris collected from improvised explosive devices

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ABSTRACT

In this study it is demonstrated that human odor collected from items recovered at a post-blast scene can be evaluated using human scent specific canine teams to locate and identify individuals who have been in contact with the improvised explosive device (IED) components and/or the delivery vehicle. The purpose of the experiments presented here was to document human scent survivability in both peroxide-based explosions as well as simulated roadside IEDs utilizing double-blind field trials. Human odor was collected from post-blast device and vehicle components. Human scent specific canine teams were then deployed at the blast scene and in locations removed from the blast scene to validate that human odor remains in sufficient quantities for reliable canine detection and identification. Human scent specific canines have shown the ability to identify individuals who have been in contact with IEDs using post-blast debris with an average success from site response of 82.2% verifying that this technology has great potential in criminal, investigative, and military applications.

1. Introduction

In recent years, the law enforcement and forensic science communities have placed focus on the determination and analysis of peroxide-based explosives due to their popularity among terrorist related threats and crimes. Peroxide-based explosives have an explosive power which becomes extremely hazardous to accidental initiation as they are usually unstable and highly sensitive to physical handling such as shock, temperature changes, friction, or impact [1]. Furthermore, the relative ease of their manufacture makes them extremely popular to synthesize from widely available household materials such as acetone from nail polish removers, acids from car batteries, hydrogen peroxide from hair dyes [2]. Some organic peroxides of important forensic and criminal investigative interest are triacetone triperoxide (TATP), diacetone diperoxide (DADP) and hexamethylene triperoxide diamine (HMTD). TATP and DADP are found as white crystalline materials. HMTD exists as a fine dry white powder which is thermally labile. The chemical structure of peroxide-based explosives does not yield for easy instrumental detection and analysis typical of explosive materials since they lack key functionalities such as nitro groups or aromatic rings which prevent the use of traditional optical spectroscopy thus limiting this type of analytical method to be used only at a minimum [3,4]. Interestingly, recent studies have demonstrated that explosions of peroxide-based explosives such as TATP are not driven by fast exothermic reactions common to nitro explosives. Peroxide-based explosives involve entropy bursts resulting in the formation of ozone and acetone molecules [5].

Surprisingly, the use of the rapid on-site detection capabilities of ion mobility spectrometry for the detection of this class of explosive materials has not been readily exploited as would be expected and limited published scientific literature is available, with an example being the implementation for the analysis of TATP in the positive ion mode [6]. Chromatographic methods such as gas or liquid chromatography have allowed for a number of trace analysis studies where both TATP and HMTD have been able to be detected at low levels. Although both analytical methodologies have been explored, GC analysis of TATP is challenging since the selectivity from the retention time and its fragmented ion can also result from other species. Furthermore, the high temperatures of GC can activate the stationary phase in short periods of time and hinder proper analysis [7–9]. Headspace GC/MS has been successfully applied to the detection of TATP traces in real post-explosion debris samples at the sub-nanogram level [10] The characterization and detection of explosive materials is important, however, it is also imperative to determine a means to link these explosive devices back to the individuals who have had contact with the device both during construction as well as delivery.

1.1. Human scent specific canines and post-blast debris analysis

Human scent is a form of trace evidence which can be obtained from objects and locations which have come into contact with an

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individual. Once collected, human scent evidence can be evaluated through the use of human scent specific canines to determine associations between people, objects and/or locations. Human scent evidence can be indirectly collected using a dynamic airflow device which traps the odor on gauze media and allows for minimal disruption of the item of interest. Various types of materials including metal, textiles, paper, and polymers have been shown to retain human scent after contact with an individual through the use of this collection protocol. Seventy-three percent of the human scent evidence collected in the United States is as a result of contact between objects and the hands of an individual [11]. A high degree of differentiation was obtained when SPME-GC/MS was employed to evaluate the types of volatile organic compounds present in a human scent sample collected from the hands, which supports the individual odor theory set forth by the ability of canines to discriminate human odors [12]. Gravimetric analyses have also demonstrated the persistence of human scent on gauze materials held in the palm of the hand for up to 3 months [13].

One of the greatest challenges of human scent as a form of trace evidence is a thorough understanding of the compounds the canines utilize when performing positive scent identifications. Human skin releases a variety of volatile metabolites which have various biological origins and that together with bacterial action contribute to the different odors. The human skin is made up of distinctive layers that allow this organ to perform its function as a permeable sheath to the human body. Each layer has a characteristic physical and chemical property according to the specific function. The outermost layer of the skin is known as the epidermis. The epidermis is a "self-renewing" layer which has an approximate thickness of one millimeter. It is made up of mostly flattened cells. The top surface of the epidermis is called the stratum corneum. Below the epidermis, one can find the skin's second primary layer, the dermis. The dermis is a composite tissue that obtains its strength from collagen fibers. These fibers are in gel-like matrix of salts, water and proteins. The most important cells of the dermis layer are the fibroblasts which are collagen rich and allow for the tensile strength of the skin. Furthermore, there is a complex structure of connective tissue fibers located in the dermis, a network of blood vessels, sweat glands, oil producing glands, and hair follicles [14]. The complexity of the definition of human odor can be attributed not only to physiological causes but also to environmental factors such as scent collection procedures, dissipation/stability of human odor, contamination issues, storage protocols [15], canine training, and handler experience which ultimately direct how effective this type of trace evidence can serve in a criminal investigation [16].

It is only within the last seven years that the survivability of human scent on post-blast debris has been realized through the evaluation by human scent specific canines. The earliest study of canines being able to associate the specific human which handled an explosive using post-blast debris was a study by the Bloodhound Handlers Coalition in 1999 [17]. A feasibility study has demonstrated the ability of human scent to survive the extreme mechanical and thermal affects associated with the explosion and burning through the ability of canines to correctly identify individuals using scent collected from exploded pipe bomb fragments [18,19]. In this study, four pipe bombs (2.7 cm $\times$ 20.3 cm Schedule 40 steel pipes) were assembled. Two devices were composed of low-order explosives composed of black and smokeless powder, respectively, and the other two devices contained high-order explosives: one consisting of a mixture of ammonium nitrate and nitromethane, and the other contained Composition C4. All four devices utilized a detonating cord booster consisting of Dupont 70-grain per foot detonating cord with a pentaerythritol tetranitrate (PETN) core. After detonation of the devices, human scent was collected onto gauze pads using the Scent Transfer Unit (STU-100). The scent pads were then stored in resealable polyethylene bags. Two weeks later, twenty dog handler teams were blind tested using simple Y-shaped trails (split trails) in which each scent target and one decoy walked a short trail together, then split apart and hid behind trees. Each canine tested had its own trail such that no two dogs worked the same trail. The test was performed in an urban park setting with layered human odor and both visual and audible distracters. The percentages of correct responses were 100, 53.8, 89.5 and 93.3 for devices 1 through 4, respectively.

Other studies have demonstrated the survivability of human odor after detonation of large vehicle bombs using explosives in increasingly large quantities. See Table 1 for a summary of related studies. A 275-pound Ammonium Nitrate Fuel Oil (ANFO) device was detonated, and two canine teams were able to successfully locate and identify the target using human scent collected from post-blast debris. Follow-up large vehicle bomb field trials were similarly successful. In 2002 (1250 lbs ANFO) and again in 2003 (2000 lbs ANFO), several canine teams were able to successfully locate and identify the target using remnants of the vehicle steering wheel recovered post-blast. In the 2002 study, teams were successful at both the blast site and in remote locations, and the 2003 study, trails were limited to remote locations only [17].

The survivability of human odor on post-blast debris items is supported by the fact that other biological material can also be recovered from items after detonation. In 2004, a study was performed that evaluated the feasibility of recovering DNA from a bomb assembler from exploded pipe bomb devices [20]. Four out of the twenty pipe bombs evaluated gave reportable results; eight other profiles were also recovered, however, they were below the established threshold. The material of the pipe bomb did not seem to interfere with the results obtained as both the metal and PVC pipe bombs gave reportable results. In another study, fingerprints were also evaluated from recovered fired cartridge casings. The enhancement techniques utilized for the recovery of fingerprints is challenging for laboratory personnel after the firing process has occurred. Even though the fingerprints were evaluated in

Table 1
Large vehicle bomb post-blast using human scent specific canines.

Explosive type and quantity	Scent source	# K-9 Teams	Trail location	Correct ID	Reference
Pyrodex muzzle loading propellant—pipe bomb	Pipe bomb fragment	2	Blast site and remote location	100%	[17]
ANFO—275 lbs	Wire, clips from device	2	Blast site and remote location	100%	[17]
ANFO—275 lbs	Steering wheel	2	Blast site and remote location	100%	[17]
ANFO—275 lbs	Pressure switch	2	Blast site and remote location	100%	[17]
Black powder—pipe bomb	Bomb fragments	20	Remote location	100%	[17–19]
Smokeless—pipe bomb	Bomb fragments	20	Remote location	53.8%	[17–19]
Binary–pipe bomb	Bomb fragments	20	Remote location	89.5%	[17–19]
C4—pipe bomb	Bomb fragments	20	Remote location	93.3%	[17–19]
ANFO—1250 lbs	Steering wheel	10	Blast site and remote location	93.3%	[17]
ANFO—2000 lbs	Steering wheel	6	Remote location	90.9%	[17]

controlled laboratory conditions; it demonstrates that latent prints are not destroyed by the high temperatures reached in combination with the expansion of the casing and the enhanced friction against the gun barrel during firing [21].

The purpose of the experiments presented here was to document human scent survivability in both peroxide-based explosions as well as simulated roadside IEDs utilizing double-blind field trials. Due to the ease of manufacture, hazards, and increased uses of peroxide-based explosives, this study presents the first field test using human scent specific canines for identification of individuals involved in the handling of concentrated peroxide-based IED componentry utilizing post-blast debris as a scent source.

2. Materials and methods

The instrument used to collect the human scent from the post-blast debris was a Scent Transfer Unit-100 (STU-100) (Tolhurst Enterprises, CA). The gauze pads used were Johnson & Johnson Surgipad 5 in. × 9 in. Surgical Dressings (Johnson & Johnson Consumer Products Company Skillman, NJ). The pads were handled using Nalgene Plastic Forceps (United States Plastic Corp. Lima, OH). The pads containing the human scent were stored in 500 mL pre-cleaned glass jars (Industrial Glassware Millville, NJ). The GPS units utilized in this study were e-Trex Vista Cx mapping handheld devices (Garmin International Inc. Olathe, KS). The wind meter was a handheld Sherpa Atmospheric Data Center (Brunton, Riverton, WY).

Canines which have been trained to perform human scent trailing start from an item/material containing the specific odor of an individual and follow that specific human's trail to the exclusion of all others; if there is no matching trail odor, the trailing canine is expected to refuse trail. It is important to clarify that the term trailing in the strict sense of the term relates to the canine's ability to work some distance from the actual footsteps. The canines in this experiment were not trained to follow footstep to footstep as is seen in tracking dogs where the dog should not vary more than one or two feet from the individual's actual footstep regardless of environmental conditions. Trailing canines are guided by the rafts of scent which may have fallen to ground along the subject's route thus allowing the canine to move from the actual step to an outer region of rafts and back again making factors such as wind of key importance due to the movement of the rafts in a particular setting. The direction of the wind can influence the position of a number of these rafts of scent from the subject allowing the heavier ones to remain close to the source while the lighter rafts can travel further away depending on the wind speed and direction.

Thirteen canine-handler teams were involved in this research study; however, not all teams participated in all areas of the experiment. Table 2 highlights the variation present among the participating teams that can be divided into five broad categories, including: gender, age, number of years of human scent specific training, previous post-blast debris exposure, and human scent discrimination. The canine ages ranged from one year to ten and a half years with varying degrees of training experience. Only five of the thirteen canines in the study had previous training experience utilizing post-blast debris as a source for human scent. Seven canine teams were previously certified by the Bloodhound Handlers Coalition; this certification consists of a blind, 24 h old, 1.5 mile test trail in an urban environment, with 12–15 turns and using a target unknown to the handler.

A total of four targets as well as a selection of non-target individuals were placed in the testing area throughout the two days of the exercise. This ensured the canines would not be able to simply locate and identify any individual present; they had to identify the correct individual. Within the four targets exists the possibility that one target may produce/release more human odor than another with provides further complexity to the test. Schoon discusses that there is observational basis noting that canines find the odor of one person easier than others, with DNA experimental data confirming that some people are defined as "good shedders" by leaving a full DNA profile behind ([22]).

This experiment was conducted across two days in the arid, desert environment of Southwestern Arizona. The terrain consisted of flatland and mild sloping hills surfaced by dirt, rocks and limited vegetation. The average temperature, humidity, and wind speed were 23.8 °C, 25%, and 13.6 mph with gusts upwards of 25 mph, respectively. This experiment was conducted in double blind fashion as none of the canine teams were aware of whom the targets were and those monitoring the trails had no knowledge of the correct outcomes of the trails. All canine teams were assigned numbers and in each of the experimental sections the order of participation for each of the canine teams was randomized, and none of the canine teams were allowed to watch any other teams conduct their trails.

For all parts of this study, experiments were conducted in double-blind fashion. The canine teams were monitored by equipping them with a GPS device to track their course away from the blast site and three video crews were placed in stationary locations throughout the experiment area. When the team indicated they had finished their exercise they were transported back to the holding area where the experimental area was out of eyesight. The outcomes of the trials were correlated at a later time.

2.1. Peroxide-based car bomb device

The peroxide-based car bomb had a charge weight of 5 kg composed with 54% of a 70% liquid peroxide and 46% of liquid nitromethane, boosted by a two ounce piece of C-4 with an electric blasting cap. The device was placed in the front passenger floorboard of the pick-up truck along with a nylon bag and simulated IED componentry, such as wires, duct tape, alligator clips and a metal box. The post-blast debris collection and human scent evidence collection was conducted by three individuals, who were all present at the start of each trial for dismissal by the canine. The post-blast debris used for human scent sources was the steering wheel, driver's side door, and the nylon bag. The human scent was collected from the post-blast items using the STU-100 which was run at the highest setting for one minute, the gauze pads were then placed into glass jars.

Prior to the detonation of the device two human scent targets were placed into contact with the blast site. Target 1 (Terrorist) handled the nylon bag and IED componentry and Target 2 (Driver) was seated inside the driver's seat of the pick-up truck. Target 2 handled the steering wheel and column, the driver's side mirror and door to simulate the places inside a vehicle contacted by the driver in regular activity. Both targets then walked from the vehicle into the village, approximately 0.5 miles, and then did a Y split and separately entered buildings (Fig. 1). The layout of the trails walked by Target 1 and Target 2 were designed as to not include landmarks or paved roads as traveled areas. The two human scent targets were equipped with GPS units to document their path from the blast site to the end of the trail. The images of the pick-up pre and post-blast are displayed in Fig. 2 to highlight the area where the post-blast debris was collected and sampled.

In order to provide realism and complexity to the experiment, an additional six people were placed in the experiment area as decoys while the teams were running their trails. This ensured the canines would not be able to simply locate and identify any individual present; they had to identify the correct individual. A decoy was placed in proximity to the targets and the trails walked by the targets. Other human odors present in the experiment area included three camera crew members placed at stationary locations as well as two additional researchers present for documentation purposes. These individuals had never been used in any previous training exercise with the participating canine teams. The identities of the decoy, the two researchers and the two targets were not known to the canine teams. In order for a canine team to successfully complete the exercise the canine would have to follow the trail of the target odor, ignore the non-target humans in the experiment, and identify the specific target without prior knowledge of direction of travel or the identity of the specific target.

The trailing exercises began approximately four hours after the trails were walked by the scent targets; during that time post-blast collection and re-positioning of the

Table 2
Canine team general information.

Team	Gender (F/M)	Canine age (year)	Training (year)	Previous post-blast training	Certification
1	F	2	1.5	No	No
2	F	8	8	Yes	Yes
3	F	3	2	No	Yes
4	F	1	1	No	Yes
5	F	5	5	Yes	Yes
6	M	2.5	1.5	No	No
7	F	2.5	1.5	No	No
8	F	7	7	Yes	Yes
9	F	1.5	1.5	No	No
10	F	1.5	1.5	No	No
11	F	10.5	9.5	Yes	Yes
12	M	2	1.5	No	No
13	F	10	10	Yes	Yes

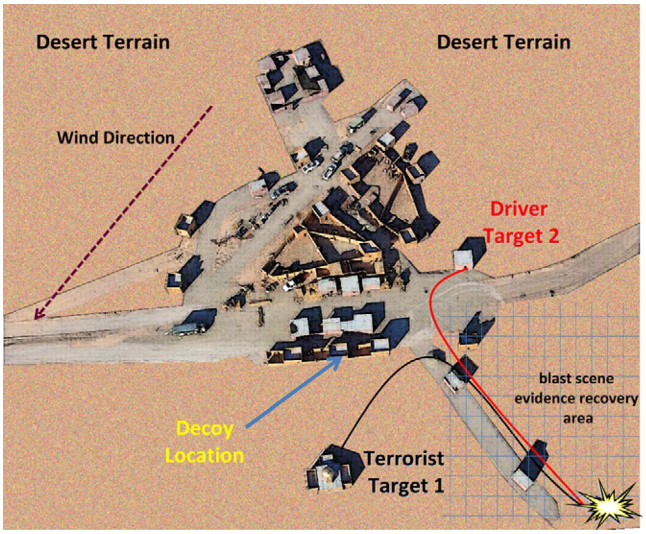

Fig. 1. Trail layout for peroxide detonation trials.

cameras occurred which provided freshly laid cross tracks over the trails laid by the targets. The canine teams were started at the front bumper of the truck and presented with a scent source without any information on the direction of the trails walked by the human scent targets.

2.2. Roadside device

The roadside device was composed of two 60 mm mortars, boosted with a two ounce piece of C-4 in each of the fuse wells. The mortars were placed approximately 15 ft from the passenger side of the delivery truck inside a hole dug by hand approximately 4 in. deep. A thermal insulated lunch pouch containing a walkie talkie, wires, and alligator clips was placed in hole with mortars to simulate IED componentry. The post-blast collection was conducted by twenty-five people walking a grid out in all directions from the blast site. The human scent evidence creation and collection was conducted by two individuals who were present at the start of each trial for dismissal by the canine. The post-blast debris used for human scent sources were pieces of the woven handle of the insulated lunch pouch. The human scent was collected from the post-blast debris using the STU-100 which was run at the highest setting for one minute, the gauze pads were then placed into glass jars.

Prior to detonation, the insulated pouch and componentry was handled by two human scent targets. Both human scent targets handled the same materials, however, only Target 3 walked a trail from the blast site into the village. Target 3 walked a trail with two turns at a distance of approximately 0.5 miles into a structure inside the village (Fig. 3). Target 4 was taken to a stationary school bus, and then walked a two turn trail approximately 0.5 miles in length terminating inside a structure (Fig. 3). The layout of the trails walked by Target 3 and Target 4 were designed as to not include landmarks or paved roads as traveled areas. The two human scent targets were equipped with GPS units to document their path from the blast site to the end of the trail.

Again, in order to provide realism and complexity to the experiment, an additional six people were placed in the experiment area as decoys while the teams were running their trails. A decoy was placed in proximity to the targets and the trails walked by the targets. Other human odors present in the experiment area included three camera crew members placed at stationary locations as well as two additional researchers present for documentation purposes. These individuals had never been used in any previous training exercise with the participating canine

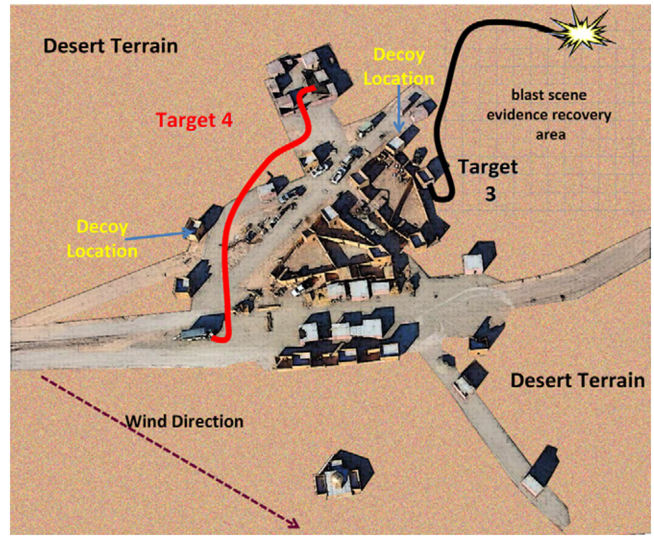

Fig. 3. Trail layout for roadside device trials.

teams. The identities of the decoy, the two researchers, and the two targets were not known to the canine teams. In order for a canine team to successfully complete the exercise the canine would have to follow the trail of the target odor, ignore the non-target humans in the experiment, and identify the specific target without prior knowledge of direction of travel or the identity of the specific target.

The trailing exercises for the first part of the experiment began approximately three hours after the trail was walked by Target 3 and the second part of the experiment began six hours after the trail was walked by Target 4. Post-blast collection by twenty-five individuals and re-positioning of the cameras occurred which provided freshly laid cross tracks over the trails laid by the targets. For the first part of the exercise, the canine teams were started at the rear bumper of the delivery truck and presented with a scent source without any information on the direction of the trail walked by Target 3. In the second part of the experiment the canine teams were started at the school bus and presented with a scent source without any information on the direction of the trail walked by Target 4.

3. Results/discussion

3.1. Peroxide-based car bomb device

The results of the canine trials from the peroxide-based car bomb are summarized in Table 3. It is important to note that, as the device items that were handled by the Terrorist target (Target 1) were placed in the cab of the pick-up truck and the Driver target (Target 2) also sat in and contacted various items in the cab of the truck, it is probable that both human scent target odors commingled and were present on the post-blast items used to create human scent articles. Both human scent targets in this portion of the experiment walked a Y-split trail, meaning that they walked the same path for a short distance to a split point, where each target then proceeded in opposite directions to their hiding locations. Due to the trail layout, irrespective of the post-blast

Fig. 2. Images of vehicle utilized for peroxide detonation.

Table 3
Peroxide-based car bomb canine results.

Run #	Pad	Trailed	Target identified	Decoy identified
1	Terrorist	Y	2	–
2	Driver	Y	2	–
3	Terrorist	Y	–	–
4	Driver	Y	2	–
5	Terrorist	Y	2	–
6	Driver	Y	[a]	–
7	Terrorist	Y	2	–
8	Driver	Y	2	–
9	Terrorist	Y	–	–
10	Driver	Y	2	–
11	Terrorist	Y	2	–
12	Driver	Y	–	–
Correct Trail:		12 of 12: 100%		
Correct ID:		8 of 11: 72.7%		

[a] Canine displayed aggressive behavior toward personnel and handler terminated the run prior to completion.

Table 4
Summary of canine trials from roadside device detonation site.

Run #	Trailed	Target identified	Decoy identified
1	Y	4	–
2	Y	3	–
3	Y	3	–
4	Y	3	–
5	Y	3	–
6	Y	4	–
7	Y	3	–
8	Y	3	–
9	Y	4	–
10	Y	4	–
11	N	–	–
12	Y	4	–
Correct Trail:		11 of 12: 91.7%	
Correct ID:		11 of 12: 91.7%	

material the human scent pad was created from, each team should have followed the trail into the village in a similar manner and then made a choice as to which target to locate. Therefore, it was not considered incorrect for a canine team which was scented at the beginning of the trail with an odor pad created from the Terrorist bag to identify the Driver, as both target odors were potentially present on the material. In addition, at the point where the target trails split, the wind was blowing around the buildings and the canine teams were directly downwind from the Driver target and upwind from the Terrorist target, resulting in all of the canine teams making the Y-split in the direction and subsequent identification of the Driver target.

The decoy and the two researchers were placed inside and around a building located at the point of the Y-split in the trail and all teams approached the building and then continued with the trail, dismissing the decoy and researchers as target human odors. During Run 6, one of the canine teams displayed aggressive behavior towards one of the videographers and the handler promptly ended the trailing exercise. Prior to the handler ending the trailing exercise the team was correctly following the human odor trail, yet there is no way to determine whether the canine would have correctly identified the target, so the data for that trail is considered only in terms of followed the odor trail correctly and disregarded in terms of identification. Resultantly, there were no false identifications made by the canine-handler teams during this portion of the experiment. As can be seen from Table 3, twelve of twelve of the canine run correctly followed the odor trail, yet only eight of twelve wholly completed the task by making a correct identification at the end of the trail.

3.2. Roadside device: part 1

The results of the canine trials from the roadside device site are summarized in Table 4. In this portion of the experiment both human scent targets handled the same IED componentry items prior to detonation. This included the woven handle of the pouch used as the source for the human scent collection. Thus, both odors were present on each pad presented to the canines.

As time passed from when the trails were laid by the human scent targets to when the canine teams ran the trails, the wind direction changed. As a result, for Part 1 of this portion of the study the location of Target 4 became upwind of the canine teams as they came around the turn in the trail that should have led them into the building where Target 3 was located. Due to this environmental change, some teams correctly followed the odor trail of Target 3 and made an identification of Target 3, whereas other teams correctly followed the odor trail of Target 3 yet when they reached the turn, picked up the odor of Target 4, stopped and then followed the odor and identified Target 4. Both identifications were considered to be correct in this study as both targets deposited their odor on the woven handle of the pouch prior to detonation. One of the canine-handler teams did not follow the correct human odor trail away from the blast site, however, all other teams followed the correct odor trail and identified either Target 3 or Target 4.

The decoy and the two researchers were placed inside and around a building next to that containing Target 3. Considering the wind direction at the time of the trails was also midway between Target 3 and Target 4, no false identifications were made by the canine handle teams in this portion of the study. However, many teams entered the building containing the decoy before continuing on with the trail.

3.3. Roadside device: part 2

The results of the canine trials from the roadside device away from the detonation site are summarized in Table 5. In this portion of the experiment, both human scent targets handled the same IED componentry items prior to detonation. This included the woven handle of the pouch used as the source for the human scent collection; thus, both odors were present on each pad presented to the canines. As the day progressed, the starting point for this portion of the experiment was upwind in relation to Target 4. Ten of eleven teams correctly trailed to the area where Target 4 was located, however, only five of eleven teams correctly identified Target 4 an one team identified Target 3. Once again for this part of the study a correct identification entailed a positive alert from the canine on either Target 3 or 4 as both individuals contributed their odor to the handled IED used. As can be observed from Table 5, the

Table 5
Summary of canine trials from roadside device away from detonation site.

Run #	Trailed	Target identified	Decoy identified
1	Y	4	–
2	Y	4	–
3	Y	4	–
4	Y	–	–
5	Y	4	–
6	Y	–	D
7	Y	3	–
8	Y	–	–
9	Y	–	D
10	Y	4	–
11	N	–	–
Correct Trail:		10 of 11: 91.0%	
Correct ID:		6 of 11: 54.5%	

results for this section for a final identification of the correct target were only a 54.5% success rate in contrast to the 91.7% success rate in the first portion of the roadside device experiment. Two teams falsely identified one of the decoys; after review of the video documentation, the false identifications appeared to be due to handler error in that the handler forced the identification. If this had been a real scenario, the canine teams would always have been started from a downwind position. However, in this experiment the starting position was firm and resulted in only half of the canine teams making a correct identification.

Among the participants of this study ages ranged from one year to ten and a half years and the training and experience were of varying degrees. Additionally, prior to this experiment, only five of the thirteen canines in the study had previous experience utilizing post-blast debris as a source for human scent and none of the teams had been exposed to post-blast debris from a peroxide-based explosive. Seven of the canine teams were previously certified by the Bloodhound Handlers Coalition; the applicability of this certification to this type of activity is unknown and therefore cannot be assumed or correlated with the results obtained.

The purpose of the study was to evaluate whether human scent survives the extreme conditions present during an explosion at sufficient levels for canine detection and discrimination; therefore, the inherent variation within the participant set allowed the experiments to be conducted and results to be evaluated without bias as to training and experience. Combining the results from the peroxide-based car bomb and the first experimental part of the roadside device, it can be summarized that there was an average success from site response of 82.2% from the participating canine teams in each of these sections of the study. Furthermore, incorporating all three sections reported above, there is an overall success rate of 73.5%.

4. Conclusions

Human scent specific canines have shown the ability to locate and identify individuals who have been in contact with improvised explosive devices utilizing human odor from post-blast debris with an average success from site response of 82.2% and an overall average success of 73.5%. This double blind study has demonstrated that human scent specific canines are competent at following a specific odor in a complex, arid, low-humidity environment, through moderate to high wind, and through areas with high cross-track site contamination. It is important to note, that extensive training is required for the canine-handler team to be able to perform these tasks as all of these teams had a minimum of one full year of training prior to the experiment. For the first time, it has been demonstrated that human scent survives the intense mechanical and thermal effects associated with an explosion where a concentrated peroxide-based explosive has been employed and can be attained from post-blast items collected from the blast site. Human scent specific canines have shown the ability to be a significant asset in the war on terror and can be utilized in immediate response to improvised explosive device detonation sites.

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References

[1] X. Xu, A.M. Van de Craats, E.M. Kok, P.C. de Bruyn, Trace analysis of peroxide explosives by high performance liquid chromatography–atmospheric pressure chemical ionization-tandem mass spectrometry (HPLC–APCI-MS/MS) for forensic applications, J. Forensic Sci. 49 (2004) 1–7.
[2] G.J. McKay, Forensic Characteristics of organic peroxide explosives (TATP, DADP and HMTD), J. Jpn. Explos. Soc. 63 (2002) 323–329.
[3] R. Schulte-Ladbeck, M. Vogel, U. Karst, Recent methods for the determination of peroxide-based explosives, Anal. Bioanal. Chem. 386 (2006) 559–565.
[4] G.M. White, An explosive drug case, J. Forensic Sci. 37 (1992) 652–656.
[5] F. Dubnikova, R. Kosloff, J. Almog, Y. Zeiri, R. Boese, H. Itzhaky, A. Alt, E. Keinan, Decomposition of triacetone triperoxode is an entropic explosion, J. Am. Chem. Soc. 127 (2005) 1146–1159.
[6] G.A. Buttigieg, A.K. Knight, S. Denson, C. Pommier, M.B. Denton, Characterization of the explosive triacetone triperoxide and detection by ion mobility spectrometry, Forensic Sci. Int. 135 (2003) 53–59.
[7] R. Schulte-Ladbeck, P. Kolla, U. Karst, Trace analysis of peroxide-based explosives, Anal. Chem. 75 (2003) 731–735.
[8] L. Widmer, S. Watson, K. Schlatter, A. Crowson, Development of an LC/MS method for trace analysis of triacetone triperoxide (TATP), Analyst 127 (2002) 1627–1632.
[9] A. Crowson, M.S. Beardah, Development of an LC/MS method for trace analysis of triacetone triperoxide (HMTD), Analyst 126 (2001) 1689–1693.
[10] A. Stambouli, A.E. Bouri, T. Bouayoun, M.A. Bellimam, Headspace GC/MS detection of TATP traces in post-explosion debris, Forensic Sci. Int. 146 (2004) 191–194.
[11] A.M. Curran, R.A. Stockham, W. Warren, B. Eckenrode. Human Scent Evidence: Scientific Support of Canine Operations and Teaching an Old Dog New Tricks (Poster and Video Display), Research Partnership Program of 34th Annual Symposium on Crime Laboratory Development, Atlanta GA May 2006.
[12] A.M. Curran, C.R. Ramirez, A.A. Schoon, K.G. Furton, The frequency of occurrence and discriminatory power of compounds found in human scent across a population determined by SPME-GC/MS, J. Chromatogr. B 846 (2007) 86–97.
[13] A.M. Curran, S.I. Rabin, K.G. Furton, Analysis of the uniqueness and persistence of human scent, Forensic Sci. Comm. 7 (2005) 1–23.
[14] N.G. Jablonski, Skin a Natural History, University of California Press, Berkeley, 2006.
[15] D. Hudson, A.M. Curran, K.G. Furton, The stability of collected human scent under various environmental conditions, J. Forensic Sci. 54 (2009) 1270–1277.
[16] P.A. Prada, K.G. Furton, Human scent detection: a review of its developments and forensic applications, Rev. Cienc. Forenses 1 (2008) 81–87.
[17] R.A. Stockham, Bloodhounds and bombing investigations, Detonator 30 (2003) 35–37.
[18] R.A. Stockham, D.L. Slavin, W. Kift, Survivability of human scent, Forensic Sci. Comm. 6 (2004) http://www.fbi.gov/hq/lab/fsc/backissu/oct2004/research/2004_10_research03.htm.
[19] R.A. Stockham, D.L. Slavin, W. Kift, Specialized use of human scent in criminal investigations, Forensic Sci. Comm. 6 (2004) http://www.fbi.gov/hq/lab/fsc/backissu/july2004/research/2004_03_research03.htm.
[20] K.J. Esslinger, J.A. Siegel, H. Spillane, S. Stallworth, Using STR analysis to detect human DNA from exploded pipe bomb devices, J. Forensic Sci. 49 (2004) 481–484.
[21] Y. Migron, G. Hocherman, E. Springer, J. Almog, D. Mandler, Visualization of sebaceous fingerprints of fired cartridge cases: a laboratory study, J. Forensic Sci. 43 (1998) 543–548.
[22] G.A.A. Schoon, The effect of the ageing of crime scene objects on the results of scent identification line-ups using trained dogs, Forensic Sci. Int. 147 (2005) 43–47.